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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
Names of authors are printed in *italics*.

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PORTLAND, OREGON: ITS CHANNEL APPROACH, HARBOR, RAILROAD FACILITIES, NAVIGABLE WATERWAYS AND TRIBUTARY TERRITORY.

BY G. B. HEGARDT, MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS.

[Read before the Oregon Society of Engineers, November 14, 1912.]

INTRODUCTION.

IN preparing this paper to be read before your Society, the writer has made the attempt to cover not only such matters as pertain to Portland itself, but also the conditions which are indissolubly bound up with the present and future progress of the city. For this reason such matters as river and harbor improvements, transportation facilities, inland waterways and extent of territory tributary to the port have been considered more or less in detail as being the principal governing factors which will have an important bearing on the future development of the port, the state and the Columbia River basin country, with Portland as its chief center.

Portland, situated at the head of deep water navigation, where ocean and inland traffic may be economically interchanged, with navigable waterways penetrating far into the interior through a territory rich in agricultural and other resources, at the junction of four transcontinental railroads which traverse the greater portion of the tributary area on most favorable grades, possesses many natural advantages and has many elements that go to make a large manufacturing, shipping and

distributing center. To continue its growth and enable it to meet the competition of other coast ports, and secure and retain its share of the increased ocean commerce expected as a result of the opening of the Panama Canal, and nearly in an equal measure for the increase in commerce due to the development and expansion of its tributary territory, it is important not only that the city provide adequate and modern harbor facilities to care for this traffic and shipping, but, perhaps, in a still greater measure that it bend every energy and permit of no delay in accomplishing the completion of the port's channel approach in accordance with the approved project improvements now under way.

The reasons which induced the founders of Portland to make a location and start a settlement on the banks of the Willamette River, more than one hundred miles from the sea, were, undoubtedly, the same that have produced similarly situated communities on other inland waterways. Water transportation then furnished the most available method of interchange of traffic with other portions of the Pacific Coast, and the only means of intercourse with the Atlantic Coast. It was but natural that they should select a site for a city on a navigable river at a point to which the light draft ocean-going vessels of that period could readily ascend, and beyond which point they could proceed no further on account of shoals or other obstructions. It established the point of trans-shipment of commodities between the ocean-going carrier and the carrier of a lighter draft or of a different kind.

With increased capacity of vessels, the coming of railroads and the expansion and settlement of the country around it and all over the coast, Portland was soon brought to realize that in order to maintain itself and keep pace with the growth of the steadily increasing commerce, it must provide the facilities necessary to accommodate the increased traffic, due to these changed conditions.

At an early date, steps were taken to improve the navigable waterway to the sea, and work on it has ever since been prosecuted with energy and results obtained that compare favorably with the efforts put forth by the authorities of other ports in this country similarly situated.

It is well to realize, however, that Portland, with its strategic position with reference to its "hinterland," favorable grades of the railroads leading to it, and its many other natural advantages, has just begun the real fight for its existence as a shipping

center; that its claim as a first-class seaport can be maintained only by the systematic and large expenditure of money, and that, in order to provide the facilities necessary to attract the modern, that is the economical, carrier, public opinion must be aroused to the necessity of giving generous support and encouragement to those who are fully aware of the situation and who are endeavoring to bring about the conditions which will accomplish the desired results. This includes not only the furnishing of a deep waterway to its docks and adequate harbor facilities for the handling of cargoes, but also the establishment and support of steamship lines and the means of supplying steamers with fuel of a quality and price obtainable at other competing ports, for it is a well-known fact that no city, no matter how favorably situated and no matter what its natural advantages may be, can depend solely and alone on its natural advantages to become a great seaport. It must be prepared to furnish facilities at least equal to those supplied by nearby ports, serving practically the same territory, for the accommodation of its shipping, to enable it not only to retain its present shipping, but to permit of its expansion as well.

The City of Portland.

While we are all more or less familiar with our city, its location and rise from a village to an important city of 240 000 inhabitants, it is probable that this paper will be read by many who are not so informed, and for their benefit, and as a means of making it as complete as possible in its more essential parts, the following general description is here made of its location.

Portland is situated at the head of deep water navigation on the Willamette River, 12 miles above its confluence with the Columbia River, and distant 112 miles from the sea, — the mouth of the Columbia River. The river passes through the city in a northerly and southerly course, dividing it into two sections, known as the West Side and the East Side, which have a combined area of 50 sq. miles. The main business district is on the West Side, where are also located the principal industries, railroad freight and passenger depots, and terminal yards. The East Side is primarily a residence district, although large lumbering plants, flouring mills, grain docks, etc., occupy the waterfront, and manufacturing plants are rapidly expanding and seeking the favorable and less costly sites offered there.

The topography of the city is favorable for expansion, easy grades for its streets prevailing throughout the business district

on the West Side and uniformly so in the entire area of the East Side. Costly grading and improvements are unnecessary for the convenient and economical intercourse between the various parts of the city, and on nearly the whole waterfront the docks are at an elevation conforming closely to the grades of the adjoining streets. The traffic between the two sides of the city is well served by five modern and commodious bridges and, in addition thereto, by three steam ferries.

As indicating the growth and financial standing of the city, the following statistics are given:

POPULATION, UNITED STATES CENSUS.

1850	821	1890	46 385
1860	2 874	1900	90 426
1870	8 293	1910	207 214
1880	17 577	1912	240 000 (estimated)

Portland in 1870 was the one hundred and twenty-third city in size in the United States, and in 1910 it was the twenty-eighth.

In 1870 San Francisco was eighteen times as large as Portland; in 1910 it was only twice as large. If present conditions continue in any great part with regard to the population of Portland and San Francisco, population curves would indicate that within twenty years Portland will have as large a population as San Francisco.

Portland is the largest lumber-producing city in the world, and in 1910 and 1911 it ranked as the leading wheat export city in the United States.

Portland's street car system in 1911, on its 252 miles of track, operated 526 cars and carried 87 050 000 passengers.

In 1911 Portland had 226 miles of hard surface paved streets, the expenditures for streets and sewers during that year being $6 486 000.

On its water-works, Portland has expended to date nearly $10 000 000. The daily supply is 71 000 000 gal.

Portland's steam railroads handled 168 152 passenger cars and 248 892 freight cars in 1911.

In 1911 Portland had more than 700 manufacturing plants, with an invested capital of $35 000 000, employing 17 000 men. The value of the manufactured products was about $55 000 000.

The Portland Railway, Light and Power Company has developed within a distance of about forty miles out of Portland, and has in operation hydro-electric plants having a combined

capacity of 55 000 h.p., and has under construction additional hydro-electric plants of about 70 000 h.p. Besides this it has, at Portland, auxiliary steam plants of 29 000 h.p.

A new company is developing 25 000 h.p. a greater distance away and is bringing its transmission lines into the city.

The city's assessed valuation increased as follows:

1900	$29 554 209
1905	131 197 561
1910	274 396 620
1911	295 332 220

The city's bank clearances increased as follows:

1890	$9 439 224
1900	106 918 027
1905	228 402 712
1910	517 171 867
1911	557 464 848

The city's building permits increased as follows:

1900	$994 985
1905	4 183 368
1910	20 886 202
1911	19 152 370

The city's jobbing trade increased as follows:

1900	$100 000 000
1905	180 000 000
1910	230 000 000

The Port's exports increased as follows:

1905 (fiscal years)	$7 708 650
1910 (fiscal years)	8 191 296
1911 (fiscal years)	9 791 225
1912 (fiscal years)	9 976 927

The Port's imports increased as follows:

1900 (fiscal years)	$1 784 172
1905 (fiscal years)	2 611 339
1910 (fiscal years)	2 427 976
1911 (fiscal years)	2 662 610
1912 (fiscal years)	2 739 841

The Port's deep-sea tonnage, inbound and outbound, increased as follows:

1900 (calendar year)	1 150 000 registered tons.
1905 (calendar year)	1 680 000 registered tons.
1911 (calendar year)	2 706 900 registered tons.

The above figures and statistics are given to show the steady and substantial growth of Portland at a time when the development of the state and the tributary area is just beginning to be felt. They may, in a measure, enable the reader to draw certain conclusions of what the city's further progress will be when the population of the state and the Columbia River Basin has doubled or trebled or in a still greater ratio increased its population and development.

Portland's Channel Approach.

Improvements of River Channel: Portland to the Sea. — In 1860 Portland had a population of only 2 847, which in 1870 had increased to 8 293; but even at this early period the necessity of securing an increased depth in the river to accommodate the greater size of ocean-going vessels, which at that time were making the port to secure cargoes, must have engaged the attention of its citizens, for in 1866 the United States began the work of improving the Columbia and Willamette rivers below Portland. But it was not until 1877 that a definite project was adopted for improving the ship channel of these rivers, covering 12 miles in the Willamette River and 100 miles in the Columbia. The 1877 project contemplated increasing the depth in the shoalest places, where there were but 10 to 15 at low water, to secure a minimum depth of 20 ft. at this stage. In 1891 this project was extended to provide a low water depth of 25 ft.

Owing to the insufficient river channel depth, it was necessary to resort to lightering the cargoes and to complete the loading of vessels at Astoria, near the mouth of the Columbia River. This continued to be done until 1893 when, as a result of the contraction work and dredging done, deep-sea vessels were for the first time able to pass fully loaded from Portland to the sea. In 1896, by taking advantage of the tide, a draft of 23 ft. could be carried.

A revised project and estimate for the 25-ft. channel was adopted in 1902, and work has been carried on under this to the present time, and completed. But with the rapidly growing commerce of the Port, before the completion of the 25-ft. project, it was evident that a greater depth was imperatively demanded to accommodate the larger vessels making the Port to take care of the constantly increasing business due to the rapid development of the Port's tributary country and the railroad development therein.

After careful consideration of the amount of the present

commerce, its past growth and the prospective demands of commerce, a project, with estimate of cost, was prepared and approved by the United States government for securing a permanent channel between Portland and the sea, with a depth at low water of 30 ft. and a width of 300 ft. The estimated time of completion of the project, if done solely by the United States, is eight years, and the cost $3 700 000, with an annual maintenance, mostly for dredging, of $350 000. In the project are included two dredges and accessories for which $520 000 has been appropriated and the contract let for their construction. Probably eighteen months will elapse before these dredges are built and in operation.

The 30-ft. project just referred to shows that from the upper part of Portland's harbor to the sea is about 116 miles; of this total distance about 36 miles require improvement, mostly by dredging, to procure the 30-ft. channel. Of this improvement, 9 miles are in the Willamette River and 10 miles in the lower estuary above and below Astoria. The remaining 17 miles are in scattering places in the Columbia River.

In the improvement of the ship channel to Portland the Port of Portland has been an important factor. This body was organized in 1891, and since that time has been continuously engaged, in coöperation with the United States Engineer Department, in the improvement of the ship channel and, during the last few years, in maintaining the channel depth of the rivers, and to the work accomplished by the Port of Portland is mainly due the satisfactory condition of the ship channel.

The expenditures on the channel from Portland to the sea to June 30, 1912, have been, in round figures, as follows:

By the United States	$2 500 000
By the Port of Portland	3 900 000
Total	$6 400 000

In these total expenditures are also included all plant employed in the improvement work, and the dry dock at St. Johns.

In the future improvement of the ship channel, the coöperation between the United States and the Port of Portland will continue, as before, but it is probable that the work will be divided, the latter handling the Willamette River dredging and the United States doing the permanent contraction work and dredging in the Columbia. As the dredging to be done in the Willamette is nearly one half of the total of the project,

the time for completion of the 30-ft. channel can, undoubtedly, be reduced from eight years to five years, as the Port of Portland, from previous experience, will promptly carry out its part of the program.

The present and under construction dredge equipment to be used in increasing and maintaining the ship channel depth will consist of six hydraulic dredges — four now in operation — with a combined maximum capacity of about 100 000 cu. yd. in sand in twenty-four hours.

The improvements made to the present time permit the uninterrupted traffic, at low water stage of the river, of vessels drawing 26 ft. Low water conditions below Portland usually occur in the months of October and November. During this period, however, the tidal effect at Portland is very marked, being as much as 2.5 ft., so that vessels drawing 27 ft. arrive and depart without difficulty by taking advantage of these tidal conditions.

Both the Willamette and Columbia rivers below Portland are essentially non-sediment-bearing streams, their waters, during the greater part of the year, being clear. The shoaling of the channel after annual freshets is due more particularly to the movement of the heavier particles along the bottom, and their deposit on the upward slope or grade of the bars when the scouring or transporting energy of the falling waters ceases, rather than to the deposit of the finer material in suspension, which is dissipated throughout the whole section of the river and deposited more uniformly and probably to a greater extent in the slacker currents, away from the channel. The channel is fixed in location. There are no sudden or radical changes due to freshets, and the annual dredging, usually done on the same ranges from year to year, shows the stable character of the banks and the slight damage done by the freshets. In only a few places in the Columbia has bank protection been resorted to, and in none in the Willamette, except near its mouth.

Improvement of the Columbia River Entrance. — The earliest known chart of the entrance is a sketch made by Admiral Vancouver in 1792. Across the bar is shown a depth of 27 ft., but the plane of reference for the soundings is unknown. The direction of the bar channel was then practically the same as at the present time.

The next survey was made by Sir Edward Belcher in 1839, when two channels were found to exist, the main channel showing a least depth of 27 ft.

About same conditions obtained in 1841, when Captain Wilkes' exploring expedition charted the entrance.

In 1868 a very extensive survey was made. At that time there was a main channel, well to the south, which carried 27 ft. at low water. Other surveys made between 1841 and 1885 generally showed two or three channels which varied both in location and depth, the latter being usually 20 to 22 ft., while the location shifted through an arc of 180 degrees.

It will, then, be seen that from the earliest known records to the time when the jetty work was well under way the best entrance depth did not exceed 27 ft. at low water, and this only when but one main channel existed. It is further known that the one-channel conditions were of short duration and the readily shifting sands at the entrance soon divided the currents into two or more channels, with the results already noted. These changing conditions were naturally a great handicap to shipping, and as the ship channel of the rivers to Portland became deepened, permitting ready access to the Port, delays became more and more frequent and burdensome at the Columbia's mouth, until loaded vessels were at times held for three to four weeks awaiting a favorable tide and a smooth bar to cross out.

Congress was at last prevailed upon to take some action looking toward the removal of this handicap to shipping, and in 1883 a project was approved for the improvement of the entrance, by the concentration of the river into one channel and its discharge as a unit to the sea by the construction of a jetty, on the south side of the entrance. Work on it was begun in 1885, at which time the low water depth was but 20 ft., with a channel unstable in position.

This project proposed a jetty having a length of 4½ miles, the construction of which was expected to produce a channel having a depth of 30 ft. at low water. On completion of the project in 1895, after the expenditure of about $2 000 000, a wide, straight channel having 31 ft. at low water had been procured. But owing to the fact that the jetty, as constructed, did not extend a sufficient distance seaward either to control the enormous sand movement or the currents to the extent of confining the channel in a fixed position, the bar channel, after 1896, began to deteriorate, the depth gradually decreasing until the year 1902, when it was only 22 ft. During this same time the direction of the channel changed from a southwest to a northwest course, the former the correct and the latter an unnatural position. When it was seen that the bar channel was rapidly drift-

ing back to the condition which existed before the improvement began, efforts were made to obtain further appropriations not only to restore but to increase the depth of 1895 and thereby put a stop to the long and costly delays to which shipping was being subjected.

A new project was adopted which called for a $2\frac{1}{2}$-mile extension of the south jetty and the raising of the whole embankment to at least mid-tide and the construction of a north jetty having a length of $2\frac{1}{2}$ miles. The combined effect of the two jetties, supplemented by dredging if necessary, is expected to produce a channel, fixed in position, having a low water depth of 40 ft. In 1903 active work began on the south jetty extension, and its final completion is expected before the fall of 1913. The total cost of the south jetty will have been about $10 000 000.

On the north jetty work was commenced in the early part of the present year, and the United States Engineers figure that its completion will be accomplished in about five years, or about 1917. The distance between the two jetties will be two miles, which will afford ample entrance width for all classes of vessels under all conditions. At the present time the low water depth at the entrance of the Columbia River is about 28 ft., and the channel width 8 000 ft., with a mean rise of tide of 7.5 ft. and spring tides of 11 ft.

With the completion of these authorized and under way improvements both at the entrance of the Columbia River and in the ship channel to the sea, the Port's channel approach may be considered equal to that of most of the inland maritime cities.

The accompanying table, Plate "A," well illustrates these conditions as compared with the present and projected harbor entrances of the principal ports of the world. It shows that the Columbia River entrance, when the authorized improvements are completed, will compare favorably with that of the most important harbors in this country as well as abroad. The authority for the projected depths of these harbor entrances is given on the plate referred to.

Portland's Harbor.

If both banks of the Willamette River and of Ross Island in the upper harbor and Swan Island in the lower harbor be included, the water-frontage within the city limits is about 25 miles. Of this about 15 miles is considered as available for deep water shipping, as the work of providing the necessary

PLATE A.

HARBOR ENTRANCES OF THE PRINCIPAL PORTS OF THE WORLD. PRESENT HIGH AND LOW WATER CHANNEL DEPTHS OR THE PROJECTED DEPTHS TO WHICH IT IS PROPOSED TO DEEPEN THESE ENTRANCES.

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AUTHORITIES:

E. CORTHELL, CONSULTING ENGINEER, NEW YORK.

H. VANDER VIN, CHIEF ENGINEER, BRIDGES AND ROADS, ANTWERP.

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OFFICE OF THE COMMISSION OF PUBLIC DOCKS, PORTLAND, ORE. NOVEMBER, 1912.

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
UNITED STATES		
Beaufort SC	17	10
Oswego NY	18	16
Velasco Tex	19	18
New Bedford Mass	20	18
Chicago Ill	21	21
Cleveland O	21	21
Duluth Minn	21	20
New Port RI	21	18
Detroit Mich	21	20
Wilmington NC	22	20
Buffalo NY	23	20
Sault Ste Marie Canal	23	21
Washington DC	23	20
Mobile Ala	24	23
San Pedro Cal	25	20
New Haven Conn	26	20
Port Arthur Tex	26	25
Bangor Me	27	13
Brunswick Ga	27	20
Wilmington Del	27	21
Savannah Ga	28	21
Providence RI	29	25
Portland Ore	32	30
Pensacola Fla	30	30
Norfolk Va	31	28
Charleston SC	31	26
Galveston Tex	31	30
Newport News Va	32	30
San Diego Cal	33	28
Philadelphia	35	30
San Francisco	36	31
Baltimore Mo	36	35
Bath Me	36	30
New Orleans La	36	35
Santa Monica	38	33
Portland Me	39	30
New York	45	40
Boston	45	35
Portsmouth NH	43	35
Mouth of Columbia Riv	47	40
Seattle Wn	Over	100
Tacoma Wn	Over	100
CANADA		
Sault Ste Marie Canal	22	22
Victoria BC	26	16
Esquimalt BC	30	30
St Johns NF	34	30
Montreal	40	32
Quebec	45	30
St. Johns NB	65	35
Halifax	83	
Vancouver BC	42	30
New Westminster		

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
ENGLAND		
Manchester	28	28
Barrow in Furness	30	17
Portsmouth	30	18
Cardiff	35	16
Blyth	34	20
Hartlepool	33	16
Middlesboro	33	16
Plymouth	42	30
Hull	45	24
Newcastle-on-Tyne	44	30
Sunderland	44	29
Southampton	48	35
London	50	30
Barry Docks	50	21
Dover	57	35
Falmouth	106	90
Liverpool	60	42
Bristol	36	
SCOTLAND		
Glasgow	32	22
Dundee	31	22
Leith	30	13
Aberdeen	33	20
Greenock	33	23
IRELAND		
Cork	27	12
Belfast	33	25
Dublin	33	20
GERMANY		
Bremen	18	11
Rostock	16	16
Königsberg	21	21
Warnemunde	20	20
Geestemunde	25	14
Stettin	25	21
Dantzig	23	23
Kiel Canal	45	45
Lubeck	28	28
Pillau	28	26
Swinemünde	26	26
Kaiser Wilhelm Canal	29	29
Travemunde	29	29
Emden	33	23
Hambourg	33	26
Harburg	33	27
Bremerhaven	37	26
Cuxhaven	43	33
FRANCE		
Bordeaux	24	20
Rouen	23	5
Bayonne	29	20
Rochefort	29	18
Nantes	28	20

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
FRANCE		
Cette	32	31
La Pallice	32	21
Havre	31	20
Calais	30	18
Dunkirk	30	19
St Nazaire	35	23
Dieppe	37	21
Boulogne	43	20
Brest	53	36
Cherbourg	56	41
Marseilles	60	60
BELGIUM		
Ghent Canal	29	29
Ostende	31	16
Antwerp	38	25
Zee Brugge	45	30
HOLLAND		
Amsterdam	32	32
Rotterdam	31	26
Flushing	33	22
ITALY		
Civita Vecchia	25	24
Venice	27	27
Spezia	26	26
Palermo	31	30
Brindisi	30	30
Savonna	30	29
Cagliari	30	26
Leghorn	30	30
Catania	47	
Genoa	52	52
Messina	165	
Naples	112	112
SPAIN		
Valentia	33	33
Cadiz	41	33
Malaga	44	44
Bilbao	52	43
Barcelona	53	49
Carthagena	60	60
PORTUGAL		
Lisbon	49	43
Leixos (Oporto)	60	46
AUSTRIA		
Triest	30	
Fiume	84	82

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
RUSSIA		
Riga	22	22
Libau	26	26
Cronstadt	28	28
St Petersburg	26	26
Odessa	30	30
Reval	30	30
Vladivostock	30	30
Sebastopol	54	54
SWEDEN		
Malmo	24	22
Stockholm	29	25
Gothenburg		
NORWAY		
Bergen	Over	40
Christiana	Over	40
DENMARK		
Copenhagen	30	30
RUMANIA		
Sulina	24	24
Constanza	28	28
TURKEY		
Smyrna	43	43
Constantinople	150	150
Salonica	90	90
GREECE		
Corinth Canal	26	26
Pireaus	48	48
AFRICA		
Tunis	23	21
Durban Pt Natal	28	23
Dar el Salaam	28	22
Bizerta	34	33
Cape Town	39	34
Suez Canal	34	34
Algiers	78	77
Alexandria		
CENTRAL & SOUTH AMERICA		
Maracaibo, Venez	15	14
Pernambuco, Brz'l	23	17
San Juan Prto Rco	25	24
Buenos Aires	27	24
Tampico, Mex	28	27
Bahia Blanca	30	18

Country	Depth of Entrance Channel at Mean High Water	Depth of Entrance Channel at Mean Low Water
CENTRAL & SOUTH AMERICA		
Santiago de Cuba	31	30
La Plata, Arg.	33	30
Vera Cruz, Mex.	34	33
Monte Video Urg	33	30
Rosario Arg.	38	21
Para, Brazil	41	30
St Thomas WI	41	40
Havana, Cuba	55	51
Rio de Janeiro	53	50
Manzanillo Mex		
Mazatan		
Valparaiso		
PANAMA CANAL		
Panama Canal	45	45
Panama	55	35
Colon	42	40
HAWAIIN ISLANDS		
Pearl Harbor	31	30
Honolulu	33	31
PHILIPPINE ISLANDS		
Manila	16	13
AUSTRALIA NEW ZEALAND		
New Castle NSW	24	20
River Yara Vict	29	26
Melbourn	30	28
Williamstown	29	27
Port Adelaide	29	23
Sidney NSW	41	36
Auckland NZ	42	32
JAPAN, CHINA BRITISH INDIA & ORIENT		
Shanghai	20	18
Calcutta	27	27
Rangoon	30	24
Yokohama	35	30
Bombay	36	29
Singapore	36	36
Colombo	36	34
Nagasaki		
Hong Kong		40

depth to the docks on this frontage is excessive neither in the amount of material to be moved nor in its cost. The material to be excavated is readily handled by suction dredges in nearly the whole distance, as there is an entire absence of rock or bowlders in the harbor.

If the lower portion of the river to its mouth be included, the frontage available for deep-sea vessels becomes 25 miles, so that greatly increased dockage facilities can be readily supplied when the shipping interests of the Port demand additional berthing space. The frontage mentioned above is based on quay construction, which will, naturally, be greatly increased by pier and slip construction, which can be used and is contemplated on a considerable portion of the Port's harbor front.

As already stated in another place in this paper, nearly the whole waterfront is favorably situated with reference to easy access to the docks, the elevation of these conforming closely to the grades of the adjoining and adjacent streets. This also makes it convenient and inexpensive to provide proper rail connections and facilities to the docks.

In the harbor, as is well known, fresh-water conditions always obtain, which is a great advantage not only in construction where wooden piles are used, but also in the effect the fresh water has on removing from ships' bottoms barnacles and other marine growth. The harbor is practically at all times free from ice. Since 1853 only on three occasions has the river been entirely frozen over, the last time in 1888. These ice conditions are of but a few days' duration, however, and modern vessels with steel hulls experience no delay.

The channel width and depth in the harbor is ample to accommodate the size of vessels which at the present time make the Port, and the plans of the government and of the Port of Portland provide for the further deepening and widening of the harbor in advance of the depth obtained in the ship channel to the sea.

A general map of the harbor is shown on the folding plate, the foot of Ross Island being considered as the head of deep water navigation. The present city boundary on the north is just below Swan Island.

Present Port Facilities.

The city has already developed, by private interests, a river frontage over five miles in length, which is now used by vessels ranging from the small river boats and coasters up to

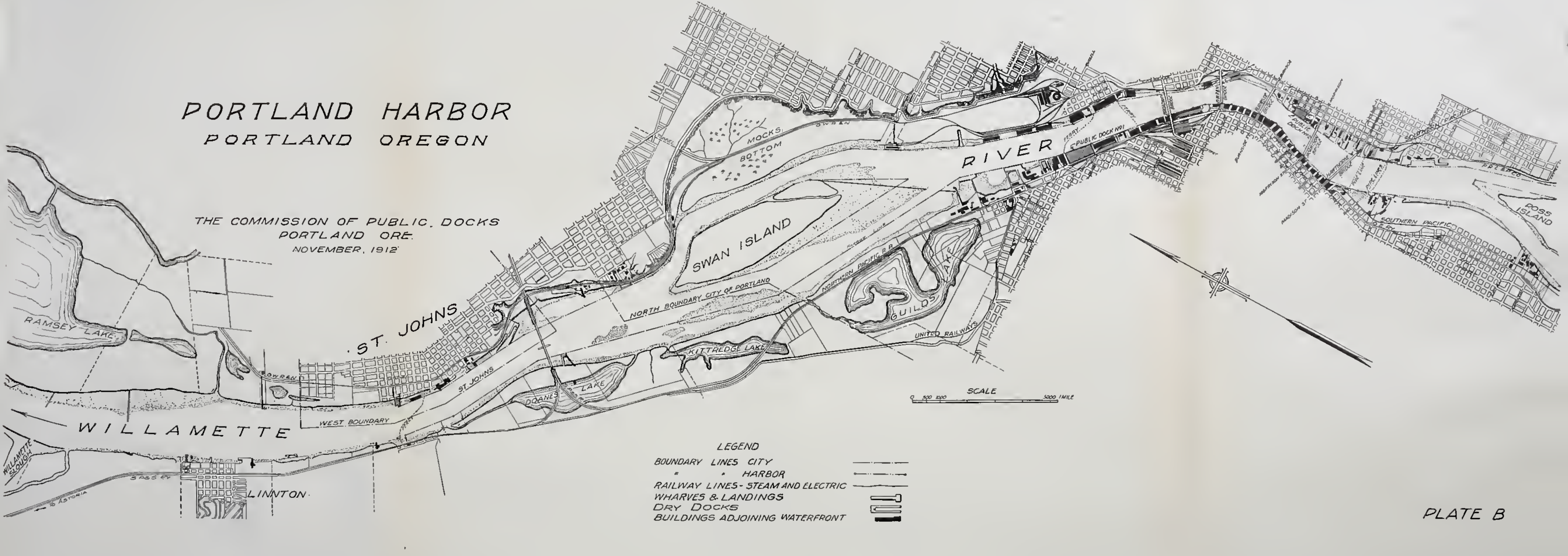

PORTLAND HARBOR
PORTLAND OREGON
THE COMMISSION OF PUBLIC DOCKS
PORTLAND ORE.
NOVEMBER, 1912
RAMSEY LAKE
ST. JOHNS
WILLAMETTE
RIVER
WILLAMETTE SLOUGH
LINNTON
TO ASTORIA
WEST BOUNDARY
MOCKS BOTTOM
SWAN ISLAND
NORTH BOUNDARY CITY OF PORTLAND
NORTHERN PACIFIC R.R.
GUILDS LAKE
KITTREDGE LAKE
DOANES LAKE
UNITED RAILWAYS
PUBLIC DOCK NO 1
PUBLIC DOCK
SOUTHERN PACIFIC
ROSS ISLAND
SCALE
LEGEND
BOUNDARY LINES CITY
" " HARBOR
RAILWAY LINES - STEAM AND ELECTRIC
WHARVES & LANDINGS
DRY DOCKS
BUILDINGS ADJOINING WATERFRONT

PLATE B

large ocean-going tramp steamers. This development has taken place on a channel which averages in most places over 1 000 ft. in width.

The principal docks for ocean carriers have a depth of from 25 to 35 ft. at low water. There are twenty-two well-constructed docks, from which about ninety per cent. of the deep-water shipping is done. These docks, varying in length from 300 to 900 ft., are all of the quay construction type. Many of these docks are equipped for handling freight economically, being supplied with derricks and electric conveyors, and about ninety per cent. of them are connected with rail transportation.

The harbor is in reality divided into two distinct parts, the upper harbor above, and the lower harbor below, the Oregon-Washington Railroad and Navigation Company's bridge. The docks above this bridge are mostly used in connection with river transportation, and the smaller class of coasting vessels, produce, package and local passenger business and light storage, although the largest class of vessels takes cargo at the sawmills located above all the bridges. These docks are, as a rule, the first built and oldest docks in the harbor. Below this bridge are found practically all the commercial docks for coast and foreign shipping, which include the grain docks, flouring mills, some of the large sawmills, elevators, coal bunkers, etc.

The construction of docks in the entire harbor up to the present time has been pile foundations and wooden superstructure.

The capacity of the ocean docks varies from 10 000 tons to 24 500 tons, the latter belonging to the Spokane, Portland & Seattle Railway Company, and the largest coal bunker is increasing its storage capacity from 15 000 tons to 20 000 tons.

The Port has two drydocks. The Port of Portland in 1903 built a sectional floating drydock just below the city limits. It has a capacity for lifting a ship weighing 10 000 tons; its length is 468 ft., inside width 82 ft., and depth over keel blocks 25 ft. The dock is equipped with electric derrick of 25 tons' capacity, and compressed air and electricity for operating tools.

The Oregon Dry Dock Company owns and operates a one-piece floating dock having a length of 340 ft., width of 60 ft. and depth over keel blocks of 18 ft. Its dead weight capacity is 3 500 tons. Adjoining this drydock is a large, up-to-date boiler and machine shop and shipbuilding yard, also capable of handling repair jobs of any magnitude.

The Panama Canal and Increased Port Facilities.

Portland, in keeping with other Pacific coast ports, is making preparations to enlarge its port facilities to care for the increased ocean commerce expected on account of the opening of the Panama Canal as well as for the increased traffic due to the development and expansion of its tributary territory.

While the opening of the Panama Canal will, to a considerable extent, revolutionize the coast's ocean-carried traffic, it is not thought the change will be very radical or sudden in its workings, for it must require several years to accomplish the readjustment of routes and rates which will affect not only the trans-ocean traffic of the United States, but also a great portion of that of the other maritime nations of the world. What will actually take place can be, of course, only a matter of conjecture at this time, but it is to be expected that municipalities will proceed with some caution in a venture of such far-reaching consequences. The development will, of necessity, be gradual to begin with, and the popular idea that very extensive and elaborate port facilities must at once be provided to meet this expected increased Panama Canal traffic, often with little regard as to cost, is not likely to be borne out by experience. This is not saying that the Pacific coast will not reap great benefit from the completion of the canal, or that the ports of the coast should lose sight of the fact that the time to get ready for the great waterway is very short and that much is to be done if they are to secure and hold their share of the business, for it is known that nearly every maritime nation expects to participate in the increased traffic and is building vessels for this new field to care for the greater business which will move by water. What is meant is that the enthusiast who expects as an immediate result a condition it must take several years to establish, is apt to be disappointed. It must be evident that such a condition cannot be immediately created, for the population of the coast cannot be at once materially increased, and further development of the area tributary to the Port is necessary before actual increase in production can take place; in other words, such development will follow gradually and must be the result of increase of population and development and not as the sole effect of the opening of the canal.

There are, however, one and possibly two products that will feel the immediate effect of the opening of the canal. The first and most important of these is lumber. This item seems to

be subject to immediate expansion due to the fact that already there are a sufficient number of sawmills constructed to permit of the doubling of the lumber output at the expenditure of very little effort and money, and by working these plants to their full capacity the output can be still further increased. Another matter in connection with the export of lumber is that it will furnish return loads for vessels which arrive with cargoes from the Atlantic seaboard, Europe and elsewhere, which is of importance as tending to balance the shipping of the various ports until the development of the coast can supply cargoes in a greater degree than is now possible.

The great fruit industry of the coast also should be largely benefited by the shipment and distribution by the way of the Panama Canal of these products in the world's markets, in the same manner as is the banana trade on the Atlantic coast.

But perhaps the more important and immediate benefits which will result from the opening of the canal will be the establishment of regular and speedy steamship service with the Atlantic seaboard, which will have the effect of reducing the cost of transportation and distribution of many commodities now brought across the continent by rail. This would also tend to lower the cost of many of the articles now consumed on the coast, and the raw material used in manufacture.

The effect of the canal should also be seen in the bringing to the Pacific coast of a desirable class of immigrants to settle on our vacant and unimproved lands and supply the demand for farm and other labor so much needed in the development of the coast's scarcely touched resources.

Therefore, it is fully believed that commercial docks or piers should be immediately constructed of such capacity as will insure the economical, speedy and efficient handling of such ocean commerce in cargo lots as may reasonably be expected to be the Port's share during the first two years, with such margin of excess dock space as will insure the keeping of the Port facilities ahead of actual requirements, until such new construction can be undertaken as will constantly provide this margin above the actual requirements. In other words, after the completion of the first unit or units of commercial docks now contemplated, the policy of the Port should undoubtedly be to await shipping developments and the results of the completed facilities before continuing with further construction.

It is further believed, if funds are available for that purpose, that the Port should acquire dock properties at strategic points

in the harbor in advance of actual occupation, so that, when additional facilities are required to meet the demands of shipping, no delay may be occasioned in commencing construction of new docks. Detailed and complete plans for the next construction unit would, naturally, always be ready for the immediate calling of bids, and as the time for completion of each unit could be judged with a fair degree of accuracy, the Commission of Public Docks would then be able to regulate the enlargements so as to keep them abreast or ahead of the demands for dock space.

It is of importance that proper facilities be also provided for the accommodations of river steamers and the smaller coasting vessels carrying passengers, produce, package freight, cement, etc. The location of such industrial docks is more properly within convenient distance of the business center of the city from which the freight may be distributed quickly and at a minimum expense to the consignee. Such industrial docks would, therefore, more properly be located in the upper harbor, that is, above the bridges, the commercial docks, of course, being constructed in the lower harbor.

Public Docks.

General. — As a result of the pressing need of giving careful and comprehensive consideration of the question of harbor facilities, to ascertain the reasons for stationary or declining shipping at one point and the rapid growth of a nearby competing port, the inadequate harbor accommodations at other points, and the necessity of harbor development on modern lines to be prepared to handle the rapidly increasing commerce of the country at large, nearly every port of consequence in this country within the last few years has made exhaustive studies of the conditions governing the more important ports not only of the United States, but more particularly the great seaports of Europe. In the reports prepared and submitted by the individuals or commissions making these investigations, particular attention has been given to the various phases of ownership of commercial dock facilities and to the powers of the management and administration at the most successful ports, those that have shown the greater increase in business and have kept their developments abreast of actual requirements.

These investigations have not taken into account the problem of design and construction of dock facilities, for they are

governed largely by local conditions, but have been nearly entirely confined to the question of ownership and the methods of organization and administration which have enabled ports with even great physical handicaps to keep their place in the front rank of the great ports of the world.

The consensus of opinion of these investigations seems to lead to the conclusion that public ownership of commercial dock facilities is the wisest policy and leads to the most satisfactory results. These investigations further showed that where one authority controlled the operations of a port the results were most satisfactory and were marked by progress and expansion of business and that the bonding and other financial powers of the Port authority should not be mixed with the general finances of the city. Experience has shown that such a course would greatly hamper and retard the work.

For several years the subject of public docks has occupied the attention of this city, and the question was brought to definite issue when, in November, 1910, an amendment to the city charter was adopted by the people, creating a Department of Public Docks, with authority to issue and sell bonds up to $2 500 000. This charter amendment provides that this department shall be administered by a commission consisting of five members, who shall be appointed by the mayor.

The Commission of Public Docks was organized in December, 1910, and is now composed of the following members: F. W. Mulkey, chairman; C. B. Moores, Ben Selling, Geo. M. Cornwall and Dan Kellaher, who serve without salary or compensation of any nature. The powers of the Commission are laid down on very broad lines. Briefly stated, the specific duties and powers delegated to it by this amendment are:

1. To prepare a comprehensive plan for the reconstruction of the harbor front for the needs of commerce and shipping. The Commission may modify such plan from time to time as the requirements of commerce and shipping and the advance of knowledge and information on the subject may suggest.

2. To provide for publicly owned docks of such number and character and on such plans as it may deem feasible and proper.

3. To purchase or acquire by condemnation such lands as may be necessary for use in construction of any publicly owned docks or any other structure.

4. To have exclusive charge and control of the wharf property belonging to the city and waters adjoining thereto, together with the operation and leasing of said property.

5. To have exclusive government and control of the entire waterfront of the city not owned by it.

6. To regulate the building, repairing, etc., of all structures on the city's waterfront.

7. To establish, regulate and alter dockage, wharfage and other rates on all public-owned docks.

Since its organization, the Commission has proceeded with due caution and deliberation in its work, and has given necessary time to study and preparation, fully realizing that the successful prosecution and completion of this important work it was created to initiate and carry out depend in a very great measure on getting started right.

The Commission has sought by correspondence and personal inspection to inform itself regarding the construction, operation and management of the most modern port developments and improvements of the principal harbors of this country and Canada, and to get in touch with the engineers who have had charge of the planning and completion of such important projects.

Upon the recommendation of the chairman of the Commission, who spent considerable time on the Atlantic seaboard making the investigations just mentioned, the Commission formulated the policy to be followed in its future work, and engaged as a Board of Consultation to the Commission the following engineers to prepare a comprehensive plan for the reconstruction of the city's harbor front: Chas. W. Staniford, chief engineer, and W. J. Barney, second deputy commissioner, of the Department of Docks and Ferries, New York City, and E. P. Goodrich, consulting engineer, also of New York City. These engineers rendered their report in April of this year and the Commission has adopted their recommendation for the sites and the construction units which are to be provided with the $2 500 000 now available. The Commission has taken steps to acquire these sites by process of condemnation and has had plans and specifications prepared for the public docks, so that everything is in readiness to proceed with the letting of contracts and commence the construction as soon as the suits now filed to acquire the properties desired are disposed of.

Immediate Improvements. — The dock facilities, approved by the Commission of Public Docks, which are to be provided with the funds now available as soon as the sites are acquired, will include the following: (*a*) Dock and shed with warehouses, on the West Side of the river; (*b*) dock and shed with warehouse,

on the East Side of the river; (*c*) coal dock, with storage facilities and coal barges; and (*d*) minor improvements.

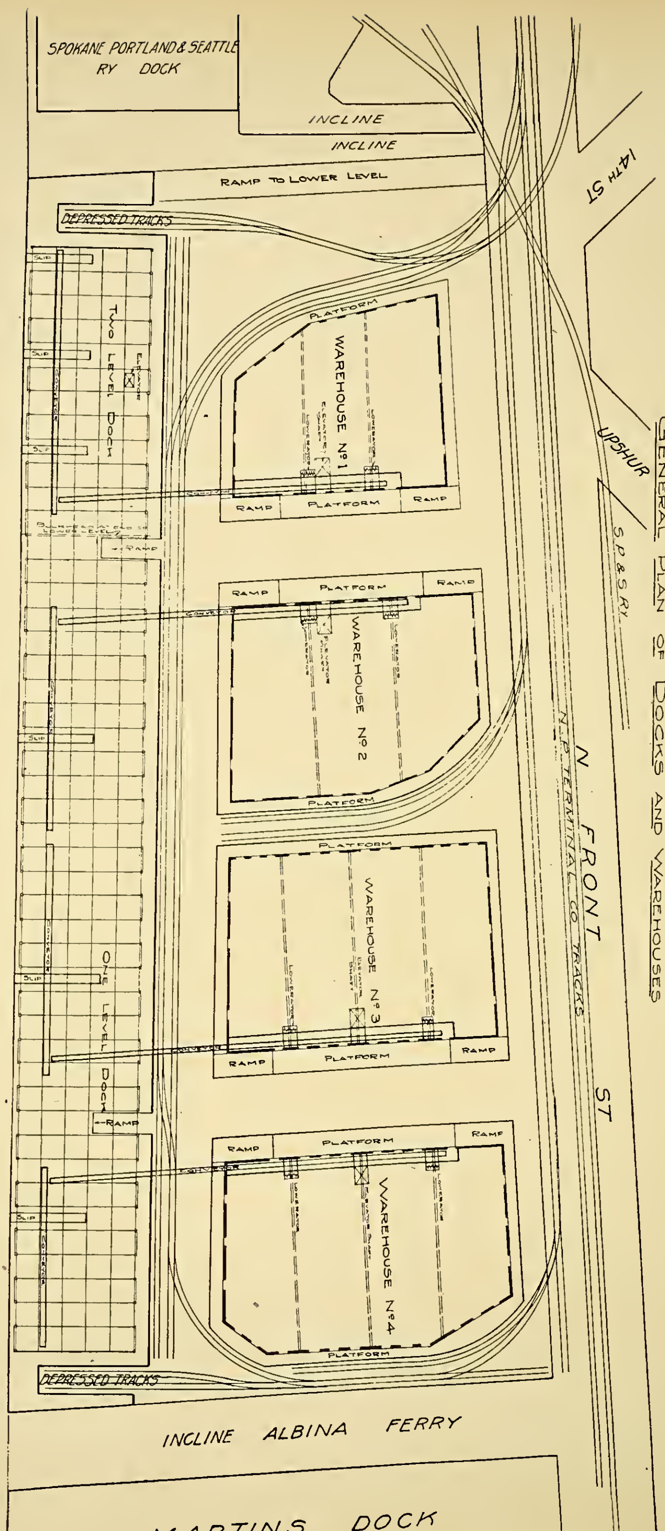
(*a*) *Dock, Shed and Warehouses.* (*Dock No. 1.*)

The site for these improvements, situated in the central part of the harbor below the city bridges and conveniently located with reference to the business and warehouse districts, railroad terminal yards and proposed municipal belt line railroad, has a frontage of 1 075 ft., and its average depth is 420 ft. It is more particularly described as lying east of North Front Street between 14th and 17th streets and adjoins the Spokane, Portland & Seattle Railway Company's ocean dock on the north. The dock itself will have a frontage of 1 013 ft. on the harbor line and is primarily designed for coastwise and ocean vessels of the largest type entering Portland. But at the same time, provision has been made for the convenient handling of freight from and to river crafts, whose importance is recognized as mediums at all docks for the assembling of outbound freight and for the distribution of cargoes received from ocean ships. For this reason 300 ft. of this dock is a two-level dock, the upper level at 32 ft. and the lower level at 18 ft. above mean low water. The northerly 713 ft. is a single level structure, with the deck surface placed at elevation 32 ft. A high level dock of 1 013 ft. in length is thus provided for large steamers, yet affording berthing space for one or two river boats.

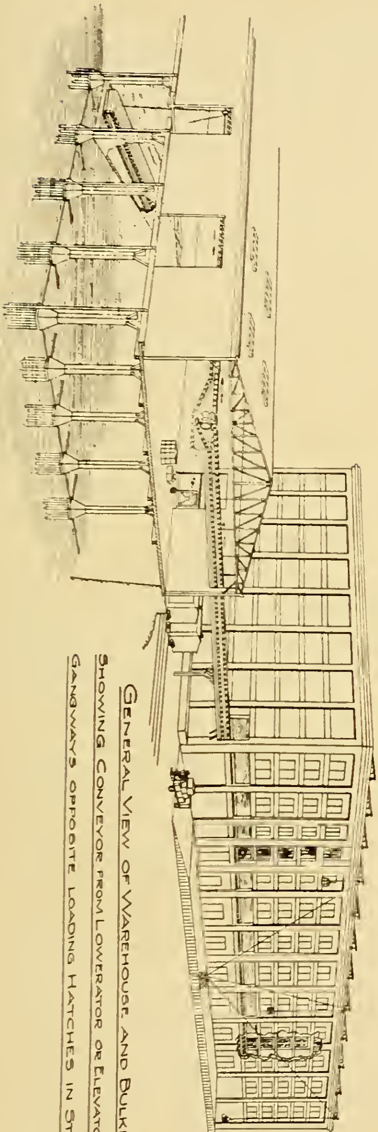
The dock is of the quay construction type and, with its shed, has a width of 100 ft. The shed area on the upper level is about 90 000 sq. ft., or, after due allowance for driveways, columns, slips, etc., ample space for the temporary storage in transit of 7 200 tons of freight; while the lower level with the floor area of 30 000 sq. ft. affords space for some 2 400 tons. Therefore, a total of 9 600 tons of freight if necessary may be temporarily stored in transit.

The double-decked section of the dock is equipped with two adjustable slips on each level. Those on the lower level have a maximum drop of 10 ft. for a length of 55 ft., a gradient slightly less than 20 per cent., or one up which a man can wheel a hand truck with a light load, or up which a stevedore and helper can wheel a full load. The maximum grade is readily mounted by a dock auto fully loaded.

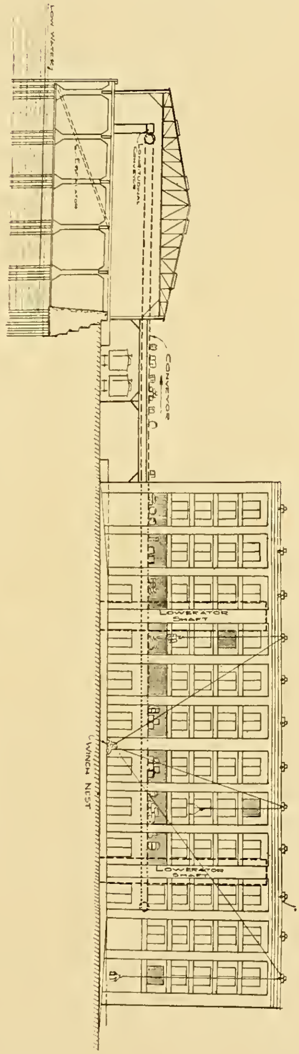
When the slip is dropped 7½ ft. or less, the grade is such (13½ per cent.) that one man can readily trundle a full load.



Dock No. 1 (West Bank).



General View of Warehouse and Bulkhead Shed
Showing Conveyor from Lowerator or Elevator Shafts to
Gangways opposite Loading Hatches in Steamer



Cross Section through Shed showing Warehouse

Dock No. 1 (West Bank).
Mechanical Merchandise Conveyors, etc.

Therefore, at practically every stage of the river up to 18 ft., from the lower level to boats and vice-versa, freight may be removed over these slips, full loads transported in every case on the dock auto, and at most times also on hand trucks. Few river boats have less than 3 ft. of freeboard even when loaded. Hence a river stage of less than 5 ft. would have to occur before the necessity would arise of a gangplank extension of these slips to reach the freight dock of a river craft. By such extension for 10 ft. the same grade can readily be carried to a boat deck at the 6-ft. level. This level minus the 3-ft. freeboard would mean a water level of 3 ft. The combination of less than 3 ft. water stage and a 3-ft. freeboard would be too infrequent to justify further cutting of the dock surface to permit of a longer slip with a lower drop.

The upper slips are also 55 ft. in length with a maximum drop of 10 ft., thus presenting the same range of grades as the lower slips, the ascendable grade for fully loaded hand trucks prevailing when the drop is $7\frac{1}{2}$ ft. or less. These slips cover fully every stage of the river from 18 to 32 ft., in the matter of handling freight to and from river crafts; since at the 17-ft. stage when the use of the lower level is discontinued a freeboard of 3 ft. places the boat deck at the elevation of 20 ft., or 2 ft. below the edge of the upper slip at its maximum drop, yet readily reached by a gangplank extension.

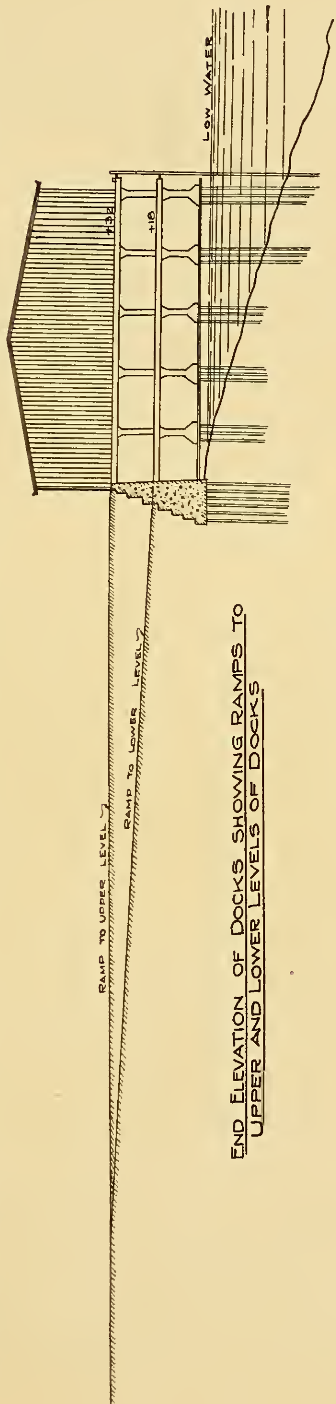
The 713 ft. of high level dock is provided with two mechanical slips or freight conveyors known as escalators. These conveyors have a maximum drop of 22 ft., with a length of 65 ft. The maximum grade of this slip is, therefore, 33.8 per cent. A slip of similar nature is now in operation on the Oregon-Washington Railway and Navigation Company's Albina Dock.

Access from the street to the lower level is afforded at the southern end by a team ramp from Front Street on a 5 per cent. grade. For extra heavy loads an electrically operated snatch tackle winch may be provided. On the west side of the lower level is installed one elevator, with a loading platform 6 ft. by 12 ft., with a lifting capacity of 7 500 lb. This elevator is for the direct transference of merchandise between the two levels. The platform is of sufficient size to accommodate one fully loaded dock auto. The elevator is to have a speed of 55 ft. per minute. Allowing for delays incident to loading and unloading of dock autos, the elevator can make a round trip per minute. Therefore, considering freight as moving only in one direction, for example, from the lower to the upper level, the

elevator can transfer one loaded dock auto per minute, or 120 tons per hour. If freight is moving in both directions, the amount transferred is estimated at $1\frac{1}{2}$ times as much, or 180 tons per hour.

The following description of freight handling devices in connection with public docks is taken from the report of the Board of Consultation:

"Reference has been made to the dock autos. They are electrically operated motor trucks of several types, capable of running loaded from four to six miles per hour, of carrying loads from one to two tons; dimensions running from $3\frac{1}{2}$ to 3 ft., 9 in. in width, and from a length of 7 ft. 1 in. to 12 ft. Their wheel base is sufficiently short to permit loaded trucks to enter and turn in box freight cars. Their power is sufficient, even when loaded, to negotiate grades from 20 to 30 per cent. One charge of electricity will operate a truck for an entire day or night at a total cost of but a few cents for power. Their operation is most simple. In practice they are generally operated with equal efficiency forward or backward by porters or even unskilled labor. They range in cost from $1 000 to $1 500. The special type of auto truck which will probably be used combines chassis with 'flat-board' bodies. This type of dock auto will carry freight from a ship to any place on the dock or marginal way or warehouse platform, yet at the same time permit of the elevation by winches of the loaded body to any floor of the warehouse



Dock No. 1 (West Bank).

without delaying the dock auto, the chassis returning to the loading point for another ' flat-board ' or load. On the ramps provided, the dock auto can enter the port of a ship, take on its load without additional manual handling, and transfer the same directly to the interior of freight cars on the service tracks at the rear of the dock shed."

Careful consideration and investigation have been given other systems of mechanical handling of freight. A telpherage installation has been considered for this dock, providing service to each of the warehouses and continuously along the front and rear of the dock shed. The cost of such a system, with a sufficient number of telphers to meet fully the requirements, when two ships are unloading, has been estimated at $75 000. Under certain conditions the same facilities for transferring freight can be rendered by dock autos for $13 000.

Telpherage may be economically installed when the volume of freight is fairly constant, when the freight is transferred regularly in given directions between given points, and when more or less regular tiering is required to heights greater than eight feet, between points which shall not be in close proximity. Floor space must be especially valuable to warrant such an installation.

Dock autos have a decided advantage in handling of general freight on account of the flexibility in installation and service, as the service can be increased by small units from time to time as experience and the volume of business justifies.

Another type of freight handling device considered is belt conveyors and moving platforms, technically termed freight carriers, which would be installed between the warehouses and the dock front.

The freight carrier could be installed at the second floor level, running along the front of a gallery, crossing the marginal way over the freight tracks at the back of the dock shed, passing across the shed to the dock front, where the merchandise could be delivered by chutes into longitudinal freight carriers. From these longitudinal freight carriers the freight could be delivered by chutes to any point on the dock front, to be picked up by slings and placed in the hatches of the ship.

Each warehouse will be equipped with two lowerators, each placed in a well. This installation would be solely for outbound cargo and could be made greatly to facilitate both the loading of the ship and the unloading of inward cargo. This system of freight delivery from each warehouse would serve some 350 ft. of dock, to any point of which delivery could be made. The

advantage of this system would be only in a definite method of operation.

The installation for each warehouse is reasonable, being estimated at $15 000 to equip a warehouse with delivery at any point along 350 ft. of the dock front. The maximum capacity of such an installation for the handling of general merchandise is about 100 tons per hour, or 1 000 tons per day of ten working hours for each lowerator operated, at a cost of about ten cents per ton for movement from the time of loading on to the lowerators to the delivery at the dock, this cost including two laborers at $3.00 per day to remove and shunt the freight from the longitudinal freight carrier.

The particular type and number of mechanical freight handling device that will be installed will be determined when their advantage has been clearly demonstrated and there is an actual demand for their installation.

The installation of dock cranes, such as are seen in Northern Europe, is not contemplated.

The custom of American ports almost universally requires the loading and unloading of ships by the vessels' own winches, or by dock winches performing like service. Most transatlantic and transpacific freight is carried in foreign bottoms, the crews of which are shipped for the round trip at some foreign port; therefore, the labor of this crew is available while the ship is loading or unloading in the American port, whereas, upon their return to the home or foreign port, the ship's crew is immediately signed off, dock labor in these ports being so much cheaper. Since stevedores in foreign ports are frequently supplied by the port authorities themselves, and almost always under at least the regulation of the port authorities, the various great ports of Northern Europe have gradually installed tremendous equipments of cranes and hoisting apparatus until their installation and use has become as fixed a custom as the use of a ship winch or a dock winch in the ports of America. A further condition of port equipment that is not usually considered by those who immediately assume that a port is not properly equipped without these cranes is the marked difference in the capacity and type of freight cars used in Northern Europe and in America. The cars in Northern Europe are only some twenty feet in length, with a capacity of twelve to fifteen tons, properly termed "wagons," and are usually of the flat car or open top type. Thus freight lifted from the hatch of a ship by one of the dock cranes can be swung inward and deposited

directly into these open "wagons," especially as in most countries of Europe there is little of any customs inspection or sorting of goods. On the other hand, in this country, our cars, some 40 ft. in length, with capacities running to 50 tons, are usually of the box car or side door type and require such clearance that a traveling crane over tracks on docks would have to be so elevated as to be extremely unstable, except at a large cost. Moreover, the progress of direct transference by such dock cranes from a ship to the cars would be practically impossible under our customs requirements.

Immediately in rear of the dock shed two loading tracks have been provided to care for the direct lateral movement of freight between ships and railroad cars. Between these tracks and the dock shed is provided an unloading platform twelve feet wide. Such a continuous platform makes unnecessary a continuous door installation in the dock shed and the care in the stopping of freight cars so that the doors of the same and the doors of the shed may coincide. A more weighty reason is that in the transference of freight between the ships and cars by dock autos, such autos are most effective where free passage is provided for their rapid movement, the dock autos leaving the ship by one of the slips provided directly across the dock surface to the platform in the rear and thence northward or southward to the railroad car to which its freight is conveyed.

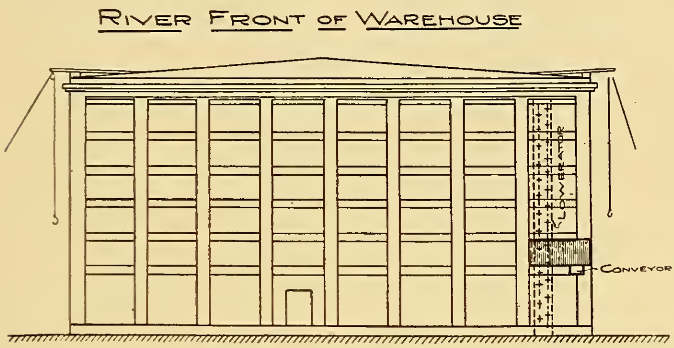
In rear of these two service tracks is provided a marginal way of 30 ft. in width, primarily designed as a place for direct unloading between teams and the eastern chambers of the four warehouses; hence the width of only 30 ft.

On the basis of tonnage handled at the average rate of 250 tons per linear foot of dock front per annum, the maximum capacity of this dock would be about 257 000 tons per annum.

In connection with this dock installation there will be ultimately constructed four fireproof, reinforced concrete warehouses — only one warehouse will be constructed with the funds now available — along the marginal way, each six stories in height, with platforms, ramps, driveways and tracks surrounding them, for the delivery and transference of freight between the dock, cars and warehouses, and teams. The east and west platforms are 20 ft. in width. The ramp is designed to permit the passage of dock autos either to the platform for the delivery of freight directly on the ground floor of the chambers or beneath the winches of the respective upper chambers for which the freight is destined.

The capacity of the four warehouses is figured at 166 812 tons and that of Warehouse No. 1, to be provided now, about 36 500 tons.

The track service to the warehouse is entirely independent of the track service to the dock, so that there will be no interference in the movement of these respective classes of freight.

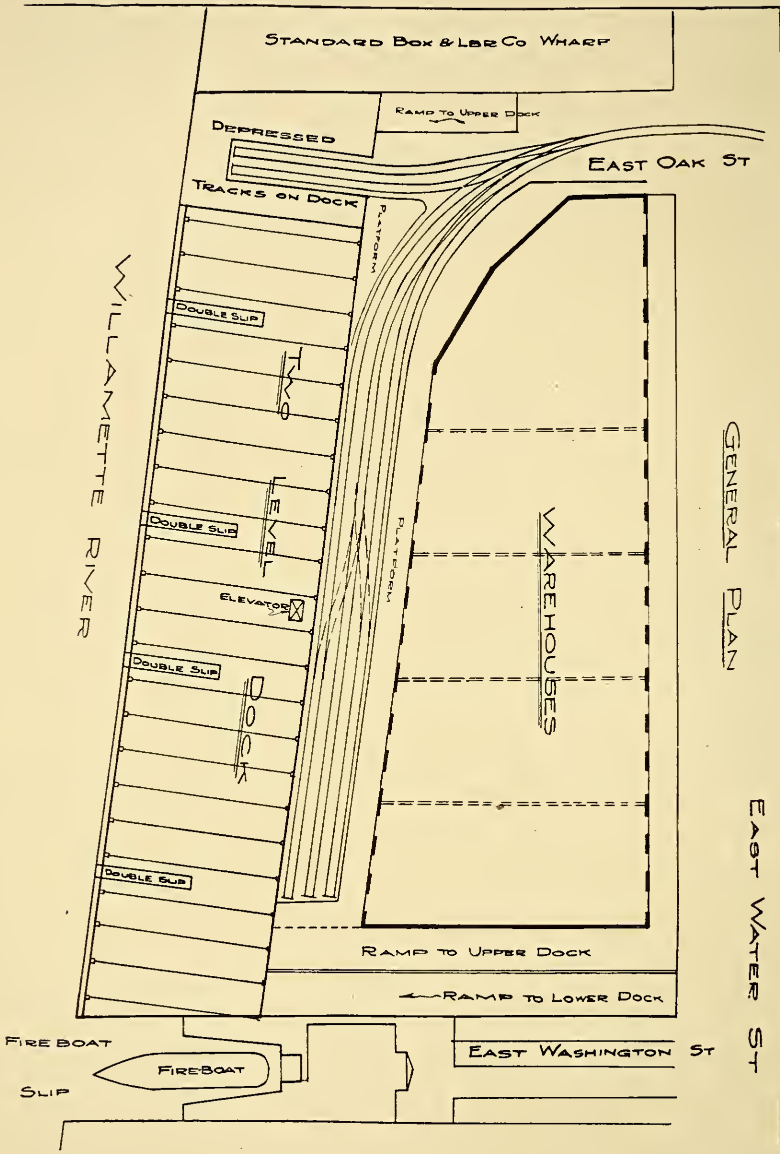


DOCK NO. 1 (WEST SIDE).

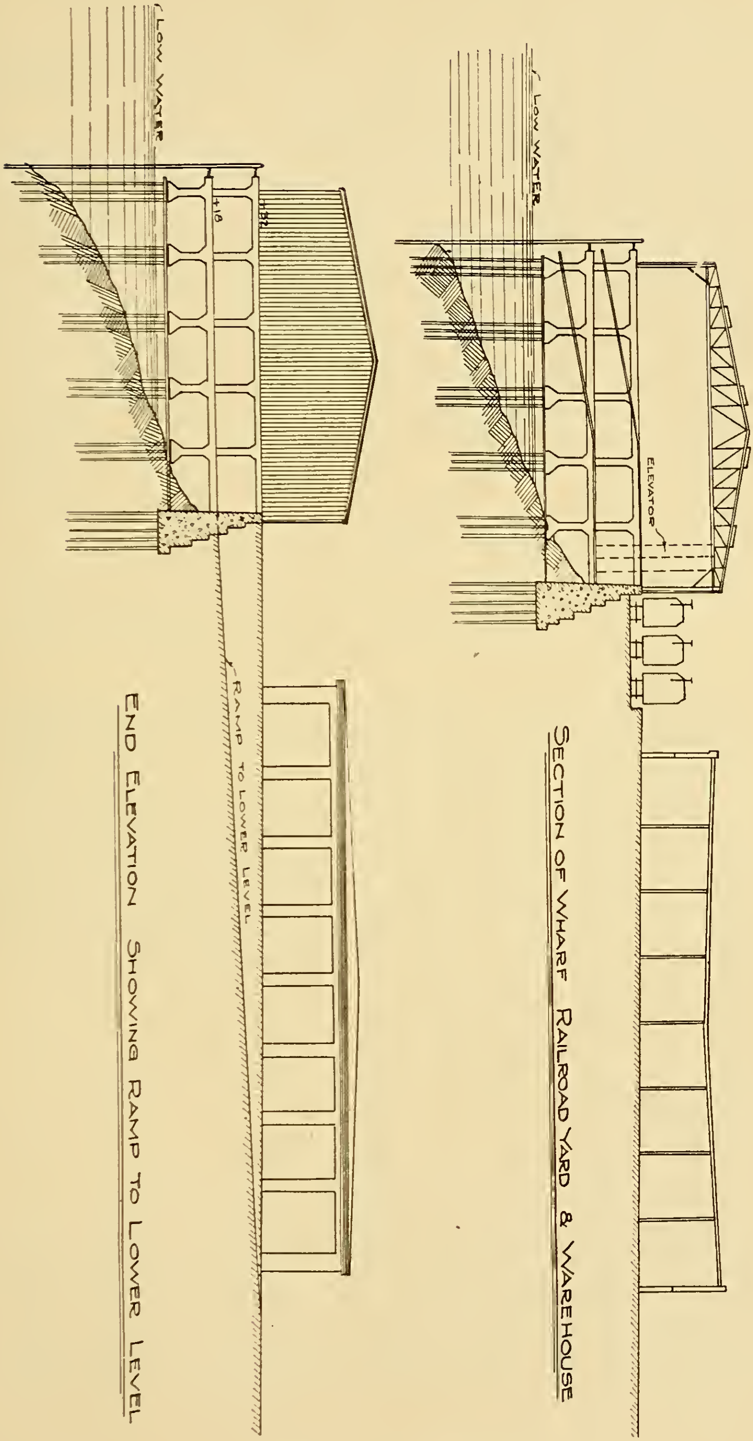
Each warehouse is provided with elevators and lowerators for transference of freight between the various floor levels, with galleries and shafts for cross-over platforms for inter-delivery between the separate chambers. Each tier of chambers in the warehouses has outward opening fireproof doors every 15 ft. Over each tier of doors is provided tackle for hoisting by winch, the simplest, quickest and most economical means of transferring freight to different levels of a warehouse. These winches are placed at one point, technically known as a nest of winches.

So far the Commission of Public Docks has not designated these warehouses for any special purpose. If freight carriers be installed they will carry all general merchandise, including grain in sacks. Under present method of grain handling it will require, upon demand for grain handling facilities, that one of these warehouses, or certain floors thereof, be assigned for the handling or storing of grain, and the installation of grain cleaning machinery. This matter will, therefore, be left to further developments.

This dock installation provides a dock equipment comprising the best mechanical appliances, whose cost of installation and service are proportionate to the funds available for them, railroad and warehouse service that will permit of the most economic and quickest assembling and distribution of freight, fireproof



Dock No. 2 (East Bank).
Quay Construction, etc.



Dock No. 2 (East Bank).

construction without undue cost or massive construction to obtain same. In short, a dock capable of accommodating three average ships at a time, loading and unloading with the greatest dispatch and storing their merchandise.

This dock development will be of fireproof construction, and, in a general way, is described as follows:

It consists of a reinforced concrete platform wharf, supported upon concrete columns founded upon timber grillages resting on piles cut off five feet above mean low water. At the back of the wharf is a concrete bulkhead wall with its top at the level of the wharf, the area back of the wall to be filled by earth or other suitable material up to grade of the street. Without loss of permanency, this combination obviates the necessity of concrete piles or concrete subaqueous foundations which add so much to the cost of dock structures when used. The column supports are placed on 20-ft. squares and connected at the grillage level by braces for lateral support.

At the wharf level, or levels, for the support of the deck, there is a system of girders and floor beams composed of steel "I" beams, encased in concrete for protection against fire and rust. This dock system further stiffens the structure.

Between the dock beams are self-supporting reinforced concrete slabs, forming the deck, which in turn is covered with wooden block or vitrified brick pavement.

The concrete columns and their pile cluster foundations in the outside bents support the steel shed columns at 20-ft. intervals, while the shed columns on the inside face are founded on the bulkhead wall.

The shed of the same width as the dock will be erected of steel of a clear span of 100 ft., and the concrete warehouses of reinforced concrete throughout.

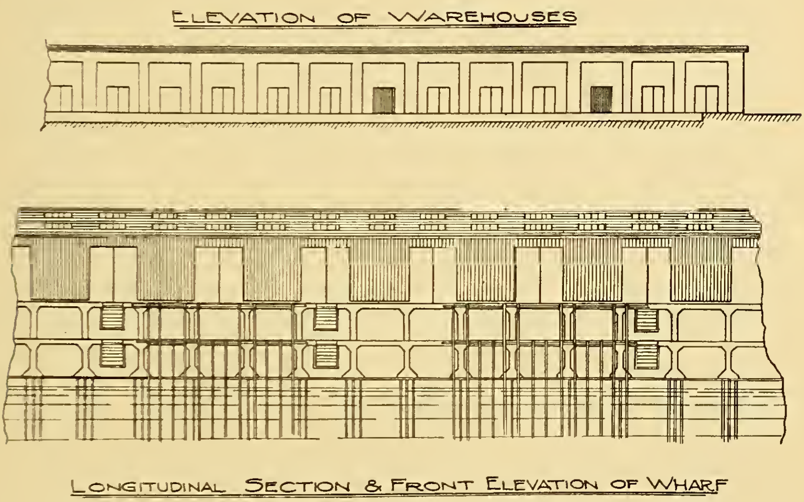
The drawings show by general plan, sections and details the dock and shed described above, a typical development of quay construction, with warehouses, trackage, marginal way, etc., adopted for public docks of the port.

(*b*) *Dock, Shed and Warehouse.* (*Dock No. 2.*)

This dock is situated in the central East Side business and shipping district, conveniently located with reference to railroad connections, proposed public belt line railroad, etc. The site has a frontage of 526 ft., is located between East Washington Street and East Oak Street, between the Morison and Burnside

bridges, and has an average depth of 305 ft. to East Water Street.

This installation is designed to serve the two immediate needs of the East Side merchants and shippers: first, a dock at which river boats can conveniently discharge or receive freight; second, wharfage facilities sufficiently ample to permit of loading or unloading of any ship now entering the harbor of Portland, and at the same time both classes of vessels are provided with direct and immediately available railroad facilities; also the freight handling facilities of the dock itself are supplemented by the immediately adjacent warehouse of sufficient proportion to permit of the receiving of river and railroad consignments to be assembled for the larger class of coastwise vessels or even transpacific steamers.



DOCK NO. 2 (EAST BANK).

This dock has two levels throughout its entire length. Each level with its depth of 100 ft. affords a maximum floor area of 47 680 sq. ft., sufficient for the receipt, temporary storage and assembling of freight in transit. It is estimated that the storage capacity in transit of each level is about 5 960 tons. This is an assumption of tiering only to 5 ft. and allowing 40 cu. ft. per ton. Thus it is seen that the dock itself, without allowing for the prompt removal of freight, has facilities more than sufficient for the successive loading or unloading of two of the largest steamers now entering Portland.

Full discussion of the various mechanical appliances for freight handling, such as slips, elevators, ramps, winches, dock autos, etc., having appeared under the description of Dock No. 1, it is sufficient here merely to indicate briefly the equipment of this dock. Four adjustable slips are provided on each level, so located as to serve either two river steamers or reach practically any part of one larger vessel. These slips are arranged in the same manner as at Dock No. 1, so as to cover directly any elevation of a boat deck from the 8-ft. stage to the level of the upper deck. Since this dock throughout its entire length is a two-level structure, the lower level at an elevation of 18 ft., the upper deck at 32 ft. above mean low water, no mechanical ramps are provided.

Access by teams to the lower level is provided by a roadway ramp 25 ft. wide at the south end of the development, at a grade of 5 per cent. from East Water Street to the lower level. Immediately north of this ramp roadway is the entrance to the upper level on a slight upgrade from East Water Street. A second access to the upper level is also provided at the north end of the dock shed, but intended primarily as a second entrance for dock autos going to and from the dock and the warehouse. Immediately north of the southerly driveway entrance to the upper level there is a 15-ft. roadway for dock autos to the 15-ft. platform, running along the west and northerly sides of the warehouse, with a ramp at the north end to the street level.

It may be noted merely that dock autos similar to the type recommended for Dock No. 1 are advised for the handling of freight at Dock No. 2.

Access to the lower level of these dock autos is provided by two freight elevators at the central point of the dock shed. These elevators have a platform of sufficient area to accommodate one dock auto fully loaded. In addition to slips and dock autos, the equipment of this dock should include four electrically operated winches and one portable dock crane.

The railroad sidings provide trackage facilities for twenty-eight cars, which permit, without car movement, of a loading of about 1 120 tons of freight. As indicated, the warehouse platform and the dock floor are on the same level as the floor of the railroad car on the sidings, the tracks being some 4 ft. below the level of either the warehouse or the dock.

The warehouse to be now built is a one-story storehouse, with a floor area of some 53 000 sq. ft. Tiering freight only to the height of 8 ft., it would provide a storage for 10 000 tons.

Many commodities can be tiered to the roof, giving 24 000 tons.

This warehouse will be moved 15 ft. in from the street line so that trucks backing up against it to receive or discharge freight will not block the street. An awning will protect the trucks from the weather.

However, the foundation of this warehouse will be designed of sufficient size to permit the erection of further floors if necessary at a later date, from future bond issue.

In this installation a terminal unit has been provided for the immediate use of the East Side for the handling of general merchandise, the receipt and delivery of heavy machinery, ample storage for freight in transit or even for longer period of storage, all at a minimum cost and with proper relation between the various parts, — a general merchandise dock.

The construction of this dock with its shed will in all respects be similar to the construction of the two-level portion of Dock No. 1, and while the reinforced concrete warehouse in rear of the dock will be built only one-story high at first, the intention is later to have six stories, as at Dock No. 1.

The above improvement, being Dock No. 2, on the East Side of the river, is shown by the drawings.

Efficient sprinkling systems will be provided at all docks and warehouses, which will be constructed in all their details to comply with the requirements of fire insurance companies, to secure their lowest rates.

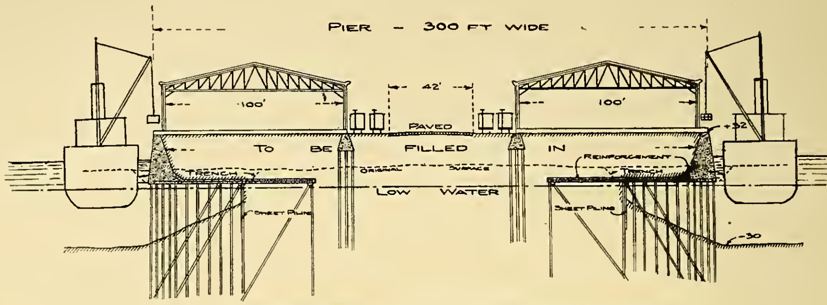
(*c*) *Coal Dock, with Storage Facilities and Coaling Barges.*

This plan provides for the construction of a coal dock below the city bridges, but the exact location has not yet been fully determined. It will have a present storage capacity of some 1 200 tons in pockets, with provision made for the doubling or trebling this capacity. In conjunction with the coal dock, four coaling barges are included, each of a capacity of 600 tons. The capacity of the storage tracks of the coal pier is sufficient to receive cars holding about 800 tons, which, with proposed present construction and the four coal barges, will permit the Commission to have on hand about 4 000 tons of coal at this dock.

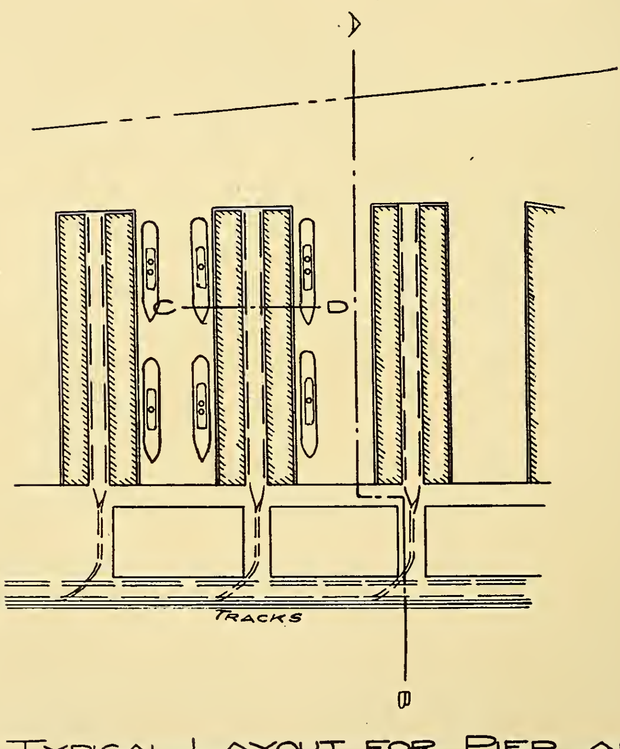
(*d*) *Minor Improvements.*

These include the construction of a motor boat landing and recreation pier at the foot of Stark Street, on the west side of

the river, a fire boat station at the foot of Albina Avenue, East Side, a floating derrick and other necessary auxiliaries of the port.

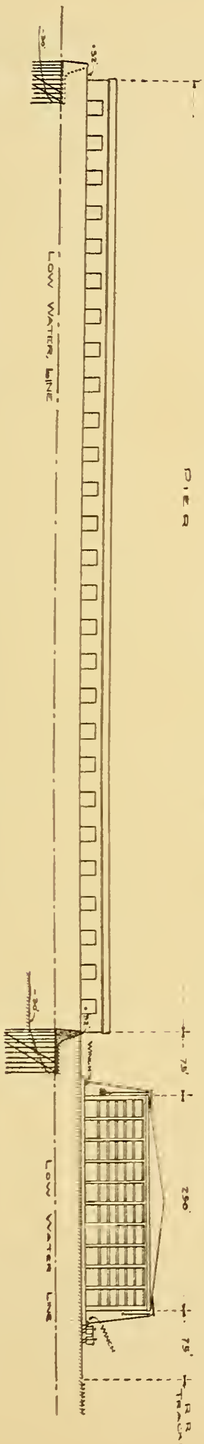


CROSS SECTION C-D, OF TYPICAL PIER



TYPICAL LAYOUT FOR PIER AND SLIP CONSTRUCTION

Future Improvements; Comprehensive Plan. — Under the comprehensive plan prepared by the Board of Consultation, it



Longitudinal Section A-B

is proposed to continue the port development in successive stages on a schedule based upon growth of Portland under present conditions, as bonding authority is obtained.

As the Commission of Public Docks has not yet made public the proposed sites for future improvements on the harbor front, it is not possible in this paper to go into details as to locations, etc., but the following outline of the additional port facilities contemplated will give a general idea of the future public docks which the Commission hopes to provide.

Following the immediate improvements which will be constructed under the present appropriation of $2 500 000, and extending over a period of years, the plan contemplates an additional expenditure of about $25 000 000, which sum covers the cost of sites as well as construction, including a public belt line railroad. The expenditure of this amount is expected to provide public docks and piers, with unloading tracks and warehouses, all united by a public belt line railroad to form one correlated and well-organized terminal port, with berthing facilities of some 32 000 linear feet — over six miles — of docks and piers. In the comprehensive plan the water front improvements proposed, both for immediate and future construction, have been divided between both sides of the river, with a common trans-shipping terminal, ample to meet the needs of the harbor for many years to come.

In this plan have been worked out the possibilities for the most improved type of grain service, and a site provided for grain elevators where grain brought

by railroads is delivered from service tracks. Grain shipments by water, such as undoubtedly will be received when the upper reaches of the Columbia River are improved, will be received in the rear of the grain elevators, there picked up by the usual suction pipes and delivered by overhead conveyor to the elevator plant. Outward shipments of grain after having been cleaned, separated, sorted, etc., in the elevator, will be delivered by belt conveyor to the piers assigned to this class of freight.

Provision has also been made for the shipment of lumber from timber areas not on streams or rivers affording logging transportation to tide water, and a considerable storage area, which may be readily increased, set aside for that purpose. One or two piers adjacent to the lumber storage area can be utilized in the cargo shipment of such lumber.

Another important feature should also be mentioned in connection with these improvements. A location has been provided for a large coal handling plant and coal yard, from which direct delivery to large ships is obtained. A space is reserved for ground storage of coal to be subsequently delivered in coal barges for distribution to any point in the harbor.

The completed improvements contemplate also a freight assembling, switching and storage yard with a capacity of 1 500 cars, and the public belt line railroad already referred to will connect all the public dock and pier units in the harbor with each other and with the trackage and terminal yard of the railroads.

In all future improvements included in the comprehensive plan, the same class of construction is provided for as outlined for the public docks and warehouses now to be constructed, that is, fireproof construction, with such mechanical freight handling devices as the service to which the improvements are assigned may demand.

The drawings show a typical plan of what the Commission proposes to construct for pier and slip development in the harbor under the comprehensive plan, the piers, sheds and warehouses to be in general as shown, with ample provision for loading and storage tracks, and such mechanical freight handling facilities as will be required for each unit at the time of its completion.

River Fluctuations and Heights of Docks.

There is one period of low water and two periods of high water in the Willamette River at Portland. The low water period is practically constant and follows directly after the annual run-off of the Columbia during September and October

and extending at times into December. On portions not affected by back water from the Columbia, the low water period of the Willamette is from June 15 to about November 1.

SUMMARY OF RIVER STAGES AT PORTLAND FROM UNITED STATES WEATHER BUREAU.

Year.	Highest from Columbia.		Highest from Willamette.		Year.	Lowest.	
	Date.	Stage in Feet.	Date.	Stage in Feet.		Date.	Stage in Feet.
1876	June 24	28.2					
1879	June 9	20.5	Jan. 1	17.0	1879	Oct. 31	1.2
1880	July 1	27.3	Jan. 9	15.8	1880	Nov. 30	0.9
1881	June 16	19.7	Feb. 7	23.6	1881	Oct. 16	1.0
1882	June 14	26.2	Dec. 16	18.5	1882	Nov. 20	0.7
1883	June 14	17.8	Feb. 2–3	16.6	1883	Oct. 25	0.3
1884	June 14	20.2	Feb. 25	12.0	1884	Sept. 30	0.5
1885	June 23	14.5	Jan. 9	15.8	1885	Oct. 20	0.3
1886	June 9	20.0	Feb. 4	17.1	1886	Nov. 6	—1.1
1887	June 21	25.7	Feb. 1	15.8	1887	Oct. 25	0.0
1888	June 18	18.2	Feb. 1	15.7	1888	Jan. 9	0.0
1889	May 21	10.0	March 20	3.6	1889	Feb. 11	0.0
1890	May 20	20.1	Feb. 6	28.6	1890	Dec. 8	—2.2
1891	June 7	14.1	Dec. 30	12.3	1891	Oct. 13–14	—0.7
1892	June 24	19.3	Jan. 5	11.4	1892	Nov. 2	0.5
1893	June 15	22.0	Dec. 3	17.8	1893	Feb. 1	1.2
1894	June 7	33.0	March 19	17.2	1894	Oct. 9	1.7
1895	May 30	16.3	Jan. 14	15.0	1895	Nov. 12	—0.8
1896	June 23	23.8	Nov. 19	19.1	1896	Oct. 15–16–30	0.0
1897	May 24	23.7	Dec. 15	14.3	1897	Oct. 1–Nov. 3	0.4
1898	June 19	20.7	Feb. 19	11.1	1898	Oct. 25	0.7
1899	June 23	24.2	Dec. 2	14.5	1899	Oct. 14	2.3
1900	May 20	17.8	Jan. 17	15.8	1900	Oct. 17	2.1
1901	June 3	20.8	Jan. 17	19.5	1901	Oct. 21–22	0.4
1902	June 4	20.8	Dec. 10–11	12.2	1902	Oct. 11–12	0.5
1903	June 19	24.0	Jan. 28	18.0	1903	Feb. 21–March 9– Sept. 29	2.4
1904	May 27	20.8	March 11	14.3	1904	Nov. 2	0.6
1905	June 15–17	13.6	Jan. 2	8.7	1905	May 15	0.5
1906	June 9	13.4	Nov. 16	15.2	1906	Oct. 9–10	1.2
1907	June 6	19.2	Feb. 8	22.4	1907	Nov. 11	1.3
1908	June 20–21	21.2	March 18	14.7	1908	Nov. 16	0.5
1909	June 21	21.6	Nov. 26	22.0	1909	Oct. 8	1.6
1910	May 15–16	19.1	March 5	19.3	1910	Sept. 13	1.0
1911	June 20	19.2	Jan. 20	12.2	1911	Oct. 29–30	0.6

The first period of high water follows the low water stage in the fall and continues to about April 1. These fluctuations, due to freshets in the Willamette, are very erratic, sudden rises and equally sudden drops producing intermittent high to nearly low water conditions. The highest recorded freshet in the Willamette at Portland occurred in February, 1890, when the flood stage reached 28.7. A remarkable fact connected with this

flood is the rapidity with which it passed off. On February 5 it was the highest known. On the first of March the gage registered 0.30. The Columbia River at this time was at a low state. The velocity of the current through the harbor when the flood was at its crest was about $4\frac{1}{2}$ miles per hour.

The second, or the Columbia River period of high water, commences about April 1 with the melting of the snows in the watershed and the flood reaches its maximum height about June 10. The rise is seldom abrupt, and when the crest has been reached the fall is exceedingly uniform until low water about September 1. The greatest height of any of the high waters of the Columbia of record was in June, 1894, when a gage height of 33 ft. was reached. Floods in the Columbia cause backwater and slack current in the Willamette at Portland. The preceding table gives a summary of river fluctuations for the past thirty-three years. The average flood height for these years is 20.6 ft., due to backwater from the Columbia, and 16.0 ft. due to freshets in the Willamette.

After a considerable study of these river conditions, and the many levels which now exist in the docks throughout the harbor and their operation during flood or freshet periods, the heights to which the public docks should be constructed were finally decided, as follows: 32 ft. for the upper deck of double level docks and for all single level docks, with a level of 18 ft. for the lower deck of all double level docks. These deck elevations will also apply to privately built docks on the city's waterfront as far as practicable, some variation to be allowed to suit the particular purpose or service to which they are to be put.

Rail Transportation Facilities.

Until very recently the railway lines of the state were located nearly exclusively in the northern and western sections. Into Eastern Oregon, with an undeveloped area approximately 250 miles square, the Hill and Harriman systems have just constructed their tracks by way of Deschutes River from the north, and the Southern Pacific has completed its line to Klamath Falls from the south, opening up this vast territory, the greater portion of which is tributary to Portland. And the Oregon Short Line is now building a line east and west across this territory to connect with the railroads already in there and, apparently, for extension to Willamette Valley for connection with the Southern Pacific main line between Portland and San Francisco.

Portland is the terminus of the following railroad systems: Union Pacific, Southern Pacific, Northern Pacific, Great Northern and, through connections, the Burlington. Of the principal interurban electric lines the Oregon Electric runs through the Willamette Valley to Eugene, and the Southern Pacific is engaged in the work of constructing a network of electric lines all through this valley and connecting its main line there by steam roads to the coast cities.

In addition to the railroads mentioned as having their terminus at Portland, there is direct connection between Portland and Canadian Pacific Railroad over the Oregon-Washington Railroad and Navigation Company to Spokane, and Spokane to Kingsgate over the Spokane International to connection with Canadian Pacific.

The greatest railroad development in the Columbia River drainage basin is in the state of Washington, with Spokane as the principal railroad center. All the transcontinental railroad and branch lines operating in the territory just described, with the exception of the Chicago, Milwaukee & Puget Sound, have direct connection with Portland on down grade to the Columbia River, and from the mouth of Snake River practically on water grade to Portland. The same conditions obtain to the south of Portland nearly to the California line, the Southern Pacific traversing the Willamette, Umpqua and Rogue River valleys on exceedingly light grades.

Inland Waterways.

The inland waterways tributary to Portland are practically all situated above the mouth of the Willamette River, the main artery being the Columbia River and the others its tributaries.

The ship channel of the Columbia from the sea to the mouth of the Willamette has already been described. Above the mouth of the Willamette, the Columbia has a low water depth of 8 ft. to Big Eddy, a distance of 92 miles. A short distance above the mouth of the Willamette is the city of Vancouver, Wash., to which a low water depth of 12 ft. is available, and an approved project contemplates the maintenance of a channel 20 ft. deep at low water and 150 ft. wide, by dredging. No improvement is contemplated above Vancouver.

The obstruction at the Cascades, some 40 miles above Portland, is overcome by two locks, each 90 ft. wide and 500 ft. in length. The depth of water over the miter sill is 8 ft. at low water, which depth is carried to the Big Eddy, the lower entrance

of Celilo Canal, where the river is obstructed by rapids for 9 miles. Here the United States is constructing a canal with five locks, each 45 ft. in width by 300 ft. in length, with least depth over the miter sill of 7 ft. at low water.

On June 30, 1912, the canal was 55 per cent. completed and it is estimated that it could be completed, ready for operation, in two years, if funds were made available. The total estimated cost of this work is $4 722 350. The state of Oregon is at present operating a portage railroad for the transfer of passengers and freight between the foot of Dalles Rapids and the head of Celilo Canal.

Between the Celilo Canal and Snake River, 124 miles, an adopted project proposes to make safe and available the channel that now exists. The minimum channel depth is 4.5 ft. at low water, and occurs at Homly Rapids, 5 miles below Snake River. The least depth at other shoals is 6 ft. at low water. There is no project under consideration for an increased channel depth in this stretch of the Columbia. From Snake River to the foot of Priest Rapids, a distance of 67 miles, the Columbia River has a greater low-water depth than exists between Celilo and the Snake. Navigation on the Columbia, below Priest Rapids, is occasionally suspended on account of ice during January. Ice conditions do not occur every year.

Priest Rapids has a length of 11½ miles and is a complete barrier to navigation, but it is understood a project is now under consideration for its improvement by locks. Above Priest Rapids to Wenatchee, Wash., the river is navigable under favorable conditions, but it is stated that at this time no steamers ply on this portion, which is 57 miles in length.

Between Wenatchee and Bridgeport, Wash., about 80 miles, the river has sufficient depth for all purposes of navigation, and the only difficulties in the way of navigation are the swift currents and reefs which occupy the channels. Continuing from Bridgeport to Kettle Falls, Wash., a distance of 162 miles, the river is navigable for vessels at certain stages of the river. The chief obstructions to navigation are rapids caused by immense bowlders and others by ledges of solid rock. Kettle Falls to Marcus, Wash., is obstructed by rapids for 11 miles. From Marcus to International Boundary and continuing to Robson, B. C., and then through Upper and Lower Arrow lakes to Arrowhead Landing, B. C., a distance of 187 miles, the Columbia River is again navigable, but information as to the period of navigation season is not available at this time. It is evident,

however, that on Upper and Lower Arrow lakes navigation is quite extensive. In August, 1910, a committee of the Portland Chamber of Commerce, at the invitation of the Board of Trade of Nelson, B. C., visited the latter place for the purpose of conferring with the Premier of the Dominion of Canada with the view of opening up the river and its improvement above the International Boundary Line, as well as south of the same. The opinion was expressed, on both sides, that improvements should be hastened on this great international highway. It is presumed it is also the intention to connect the Kootenay Lake territory with the Columbia River system.

Okanogan River, Wash. — This river, a tributary to the Columbia, is navigable for light draft steamers for about four months each year, April to July inclusive, for the distance of 87 miles from its mouth. During low water navigation is obstructed in places by shoals and rocks.

Lake Chelan. — From Columbia River at Lakeside to Stehekin, at the head of the lake, steamers ply regularly. The distance is 50 miles. Chelan Falls, near the Columbia, interrupts navigation between the lake and the river.

Snake River. — The head of navigation on the Snake River, under existing projects, is at Pittsburg Landing, 216 miles above the mouth of the river. The present head of navigation is at Asotin, 7 miles above Lewiston. The governing low water depth between Columbia River and Riparia is about 24 in. Between Riparia and Lewiston the present controlling depth at low water is about 40 in.; the existing project provides for a completed channel depth of 5 ft. Above Asotin the slope of the river rather than the depth of channel is the controlling feature. Navigation between Columbia River and Riparia is usually suspended during August and September, due to low water. Ice conditions usually occur during January and February and entirely suspend navigation, but these conditions do not occur every year. It is estimated that three favorable working seasons will complete the existing projects.

The present low water depth can be increased without the use of locks and dams, which have not been considered on account of the cost, but it is probable that future projects will consider the use of lateral canals with locks, or locks and dams.

Willamette River. — This river is navigable to Eugene, 171 miles, during favorable stages. At the falls of the Willamette at Oregon City a flight of four locks, each 210 ft. long and 40 ft. wide, having a lift of about 10 ft. each and depth over the miter

sills of about 2 ft., were built in 1873 by private interests. The United States, in coöperation with the state of Oregon, under approved project and appropriations made for that purpose, will, in the near future, construct an entirely new canal and locks around the falls, which will greatly benefit navigation. The locks will be four in number, 45 ft. wide, 300 ft. long, and have a depth of 6 ft. on the miter sills at low water; Clackamas Rapids will be improved accordingly. The estimated cost is $754 000.

The river is now navigable at nearly all stages to Independence, 83 miles, for light draft steamers, the governing depth being that over the miter sills of the locks and at Clackamas Rapids, below Oregon City; to Corvallis, 119 miles, during seven months of the year, and to Eugene during the higher stages of the river. A slackwater, lock and dam, project is at present under consideration for the improvement of this river. The low water slope of the river for the first 53 miles below Eugene, to Corvallis, is 3.8 ft. per mile. Below Corvallis, to Newberg, 81 miles, the average low water slope is 1.6 ft. per mile. Below Newberg slack water obtains, at low water.

Yamhill River. — By the construction of lock and dam this river, a tributary to the Willamette, has been made navigable for a distance of 18 miles above its mouth.

Summary of Navigable Waters of Columbia River and Main Tributaries, above Portland.

	Navigable Miles.	Obstructed Miles.	Improvements.
Columbia River:			
Mouth of Willamette to Big Eddy, lower entrance to Celilo Canal	92		
Big Eddy to upper entrance Celilo Canal,		9	55% completed.
Celilo to Priest Rapids	191		
Priest Rapids		11½	None.
Priest Rapids to Wenatchee	57		
Wenatchee to Kettle Falls	242		
Kettle Falls to Marcus, Wash.		11	None.
Marcus to Arrowhead Landing, B. C. ...	187		
Okanogan River	87		
Lake Chelan	50		
Snake River (project 216 miles)	146		
Willamette River	171		
Yamhill River	18		
Total	1 231	31½	

As the obstructions in the above rivers in most cases are not of a serious nature and the cost of removing them is not, as

a rule, prohibitive, it is reasonable to expect that the whole length of the Columbia from the mouth of the Willamette to the International Boundary will, perhaps, in the near future receive the attention of the government and be improved for continuous navigation for ordinary river crafts.

Below Portland are several small tributaries to the Columbia which afford navigation during the greater portion of the year. The combined length of their navigable portions is about 100 miles.

Territory Tributary to the Port.

As the business of the port depends in a great measure on the volume of traffic originating in the territory tributary to it and on the convenience and cost at which products can be brought to the docks, a short reference will here be made to this territory, its extent, present development, etc.

Broadly speaking, the area tributary to Portland includes all of Oregon and the territory of the states of Washington, Idaho and Montana lying within the Columbia River Drainage Basin, with an area amounting to about 240 000 sq. miles. The population in this vast territory in 1910 was, in round figures, 1 700 000, or about 7 to the square mile.

As a matter of comparison, the following group of Eastern States, embracing Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, Pennsylvania and Ohio, has a combined area of 246 470 sq. miles, a slight excess over the area of the Columbia River Basin, but its population is 34 194 649 (1910 census), or twenty times that of the latter territory.

The state of Oregon has an area of 96 000 sq. miles, with a population of about 800 000, or less than 9 persons to the square mile. Of the 61 000 000 acres contained in the state's area, 33 per cent., or 20 000 000 acres, is classed as agricultural land. Twenty-two per cent. of this, or 4 400 000 acres, is improved land, of which about 600 000 acres are irrigated. It is estimated that at least 3 000 000 acres are susceptible of irrigation. Agriculture is the largest productive industry of the state; in fact, it is the basic industry of the state. Oregon is supposed to have a fifth of the merchantable timber of the United States, or about 400 000 000 000 ft., distributed along the coast, the Cascade Range and in the eastern section of the state. The area lying west of the Cascade range of mountains contains about 70 per cent. of this total. At Hood River and in the Umpqua and

Rogue River valleys are the great fruit-producing districts, in eastern and central Oregon the wheat belts and cattle industry, and in the coast counties, with their mild climate and bountiful rainfall, the principal dairy business.

In the state of Washington, the territory lying east of the Cascade Mountains and more directly tributary to Portland than to the Puget Sound cities by reason of more favorable transportation by water and on water grades contains that part of the state generally known as the "Inland Empire" on account of the variety and greatness of its resources. In this region we have the great wheat belt, which produced in 1912 70 000 000 bushels of wheat, and the great fruit districts of Yakima, Wenatchee, Spokane, etc. The counties in Washington in the Columbia River Basin aggregate 37 400 sq. miles, and in 1910 had a population of 398 880, or 10 persons to the square mile. Of the state's 24 000 000 acres in the Columbia River Basin, about 6 000 000 are in cultivation, of which 350 000 acres are under irrigation and an additional 1 600 000 are susceptible of irrigation. The timbered area lies mostly west of the Cascade Mountains.

The state of Idaho embraces an area of 84 000 sq. miles. The Columbia River and its tributaries drain the entire area, except a small section on the southeastern part of the state. The acreage of the state is about 55 000 000 acres, classified as follows: 21 000 000 acres agricultural land; 5 000 000 acres mineral land; 20 000 000 acres timber land and 9 000 000 acres grazing land. About 5 000 000 acres are in cultivation, of which 2 400 000 acres are irrigated, and statistics of the state show that a total of nearly 10 000 000 acres can be put under ditch. The population of Idaho in 1910 was 325 594.

Only about 25 000 sq. miles of Montana are in the Columbia River watershed and include the Flathead Irrigation Projects, which contemplate the reclamation of some 150 000 acres.

The great basin traversed by the Columbia River and its tributaries contains at least one third of the available water-power of the United States. According to the United States Geological Survey over 9 000 000 h.p. can be developed in the Columbia River watershed in the states of Oregon, Washington and Idaho, estimated at average minimum flow of streams, without storage. As only about 6 per cent. of the available water-power of these states has been developed, it is difficult to appreciate the enormous value of this natural resource and the important part it will play in their development in furnishing power for

transportation, manufacture, irrigation, domestic use and for fertilizing purposes, and as power development becomes more general, electric heat will be produced and sold in the arid and treeless regions at least as cheap as coal and wood. And the improvement of the inland waterways to their maximum will add greatly to the immense traffic which must flow in and out of the Columbia from the constantly growing hinterland with its prospective enormous increase in inhabitants and its boundless resources of the soil and the forests.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by February 15, 1913, for publication in a subsequent number of the JOURNAL.]

ASSOCIATION
OF
ENGINEERING SOCIETIES.

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THE DIESEL ENGINE AS MOTIVE POWER IN THE MERCHANT MARINE, WITH SPECIAL REFERENCE TO THE FIRST SUCCESSFUL MOTOR SHIP, "CHRISTIAN X."

BY OLE K. OLSEN, MEMBER OF THE LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, October 14, 1912.]

THE subject of the Diesel engine and its relation to the merchant marine means nothing less than a revolution in ship propulsion.

It may be in order to give a very short résumé of the development of the internal combustion engine, as history shows that the idea of employing the expansion force of air and fuel directly in the working cylinders dates back to the days before the advent of the steam engine.

Gunpowder. — In 1670 to 1680 it was proposed by Huyghens and Papin to use gunpowder as fuel, — which is the earliest suggestion we know of.

Gas Mixtures. — In 1791 English patents were issued for a kind of a turbine in which gases which were generated from fuels were to be used with air and water and were to exert their forces in the turbine after having been ignited, and in 1794 we find another English patent covering an oil engine where the fuel was to be evaporated in the cylinder itself and ignited by flame after half of the stroke had been completed.

In 1801 M. Lebon took out French patent for a double-acting engine using two pumps for mixing and compressing air and illuminating gas in a reservoir, and from there forcing it to the double-acting working cylinder where it was electrically

ignited. Several other patents were issued, especially in England, during the following years, covering various internal combustion and explosion principles.

Otto. — About this time a young German merchant built an experimental engine, the principle of which was based on admission of the mixture of gas and air, compression, ignition and exhausting of the spent gases, all in one cylinder. It was anything but a success, and, discouraged over the apparent failure, he constructed the Otto atmospheric engine, a vertical machine, where gas was admitted under the piston, the piston was driven upwards by the combustion of the charge, and transmitted power to the shaft and flywheel on the downward stroke only when actuated by atmospheric pressure. Some five thousand of these engines were built, and some are still in operation. A French engineer, Beau de Rochas, proposed the idea — but never put it to a practical test — of using four strokes to a cycle and compressing the charge before ignition in the working cylinder; and in applying this principle to his first experimental engine, Otto developed the first practical 4-cycle engine, generally known as the Otto engine.

Some inventors went a step further and constructed a 6-cycle engine, expecting to get higher economy by using a third stroke to admit pure air and expel it again after the spent gases had been exhausted, but their hopes were not realized.

Diesel. — About 1893 Prof. Rudolph Diesel, of Germany, designed what is now known all over the world as the Diesel oil engine. His engine is not an explosion engine, but a combustion engine, and the principle is, in short, as follows: Pure air is drawn into the cylinder and compressed to a point at which the temperature of the air is equal to or higher than the combustion temperature of the fuel used, generally from 350 to 550 lb. per square inch. Just as the piston starts on its outward stroke, the fuel is forced in under a slightly higher pressure than that in the cylinder, and in the form of a fine spray. The high temperature of the compressed air forces the fuel to ignite instantaneously and burn as it enters the cylinder. The temperature of the gases is thus kept constant during the combustion, and no explosion takes place.

Lenoir. — The first practical engines, however, did not appear until M. Lenoir, in 1860, built a one horse-power double-acting gas engine with 3-in. diameter, 5½-in. stroke.

Marine Use. — We shall now go over to the latest success of the Diesel engine in its application to the merchant marine.

A great many experiments have been made to successfully use the internal combustion engine for marine use, and it is, of course, well known that this motive power has been exceedingly successful for smaller craft, but notwithstanding the fact that the leading countries of the world have invested fortunes in experiments, they did not succeed in bringing out a type of engine suitable for the great freight carriers, and it was not until January, 1912, that the first large motor ship made its appearance. This boat, *Selandia*, was built by the Danish ship and machine builders, Burmeister & Wain, in Copenhagen, Denmark, and we have recently had her sister ship *Christian X* in the port of New Orleans after her first trip across the ocean.

Burmeister & Wain had built several ships for the Danish East Indian Steamship Company, and as the firm had been very successful in building stationary Diesel engine plants of large dimensions, the steamship company and the builders decided to make the experiment which turned out to be a success, so much so, that six months later, the Burmeister & Wain Company had orders on their books for twelve more boats for various nations.

"Christian X."

The ship is 370 ft. long, 53 ft. beam and 30 ft. deep. She carries 7 000 tons and will make 12 knots (13.8 statute miles) with full load, and her two main engines of the Diesel type develop each 1 250 i.h.p. She has two secondary engines not used for propelling, developing each 250 i.h.p. At the trial run she developed 1 700 i.h.p. in each of the main engines and obtained a speed of $12\frac{3}{4}$ knots.

General. — The machinery, except the winches on deck and the steering gear, is all in one room, in order to make everything as accessible and economical as possible as regards the attendance.

Attendance. — Under normal conditions one engineer and two assistants are needed, and while the assistants are looking after all secondary machinery, the engineer has from his operating room full view to the main engines, switchboard, fuel oil pumps, oil tanks, etc.

The full engine crew consists of three engineers, six assistants, one electrician and two boys for cleaning up, etc., and the same size steamship would need five engineers, two or three oilers, one electrician and ten to twelve firemen.

Machinery. — The machinery consists of two main engines, two secondary engines, two motor transformers, two cooling

water pumps, two lubricating oil pumps, one fuel oil pump, ballast pump, ice machine, various air compressors, two generators, one small donkey boiler, one fresh-water pump and one evaporator.

Main Engines. — The main engines are 4-cycle motors directly connected to propeller shaft. Each engine has eight cylinders of $20\frac{7}{8}$ in. diameter and $20\frac{3}{4}$ in. stroke and makes 140 rev. per min., corresponding to 12 knots per hour. There are two of these.

Secondary Engines. — The secondary engines are ordinary stationary 4-cycle Diesel engines. There are two of these and each has four cylinders of $12\frac{3}{4}$ in. diameter and $17\frac{1}{4}$ in. stroke. The number of revolutions is 230 and indicates at normal load 250 h.p.

Air Compressors. — The air compressors for the main engines are single acting pumps taking the air at 300 lb. pressure from the receiving tanks or supply tanks, and compressing it to approximately 900 lb. in one cycle. From these compressors the air is carried to separating tanks where oil and water are separated from the air, and from these tanks it goes to the fuel valves of the engines to be used in injecting and atomizing the fuel oil. A disk valve is used instead of the ordinary needle valve, and it opens into the cylinder, which gives better atomizing and, therefore, more complete combustion.

The compressors are driven by an overhanging crank placed on the front end of the crank shaft and are constructed so that they can work with either half or full stroke. Under normal conditions half stroke is ample to furnish the engines with sufficent air for injecting and atomizing, but in case one compressor should get out of order, the other can feed both engines for full speed.

Starting. — The starting of the machinery is, as for stationary engines, by compressed air, but the operating pressure is here only 300 lb., as the compressed air is used for starting the engines as well as for stopping them when a quick reversing is desired; for instance, from Full Speed Ahead to Full Speed Back.

In cases where the speed of the ship — by its momentum — through the action of the water on the propeller, keeps the engines running a long time after the fuel oil has been taken off, the operating air is used as a contra force to stop the engine before it is started the other way, and in order to avoid explosions, the cylinder head is furnished with a safety valve.

Reversing. — A horizontal cam shaft which carries the steering cams which give the valves in the cylinder heads their movements has two sets of cams, one for Forward and one for Back. This shaft is placed on a level with the cylinder bottom, and for the valve motion one rod is used for each valve, or four rods for each cylinder, as follows: For starting valves, air inlet, fuel oil and exhaust. These rods are at the top connected to the lever arms of the valves, and at the bottom they carry rollers which run on above-named steering cams. These rods are also linked to the cranks on the operating shaft, which is parallel to the cam shaft and runs the full length of the engine.

The reversing operation is as follows: By means of the reversing engine in the operating room — a small two-cylinder air-driven engine which can be revolved both ways by directing compressed air to either side of the piston — the operating shaft may be turned either way, according to whether valve motion for Forward or Back is desired, and as the operating shaft is being turned it pulls, by means of above-named cranks, the valve rods outwards so that the rollers are pulled away from the steering cams. Then, when the cams are entirely free from the rollers, the horizontal cam shaft is automatically shifted lengthwise by means of guide rollers with a guide curve on the operating shaft, so that the set of steering cams, corresponding to the movement desired, comes into position, and then, finally, the rods with the rollers are again pulled in on the steering cams. It takes about 15 sec. for the reversing engine to change the valve motion from Forward to Back.

Fuel Oil Pumps. — The fuel oil pumps are the usual ones, two for each engine, the one being reserve for the other. Under normal conditions both pumps are working, but in case of accident one of them is sufficient to run the engines at full speed. The quantity of oil — and thereby the number of revolutions of the engine — is changed by regulating the suction valves on the fuel oil pump, as these are kept open for a shorter or longer time by the compression stroke according to the position of the lever arms of the valves.

These lever arms are regulated by means of an axle which is turned by an operating lever which has a handle with a small pawl, which engages a sector with very small teeth, so that this handle when engaged in a certain position determines the number of revolutions. The same operating lever engages on the front part of above-named sector a slide valve which is placed in the pipe which leads the operating air from the service tanks to the

starting valves. As the handle is moved forward from "Stop," said slide valve is first lifted into a position allowing air to pass through the starting valves on to the pistons, and when the engines have obtained sufficient speed to light the oil — by running three or four revolutions by compressed air — the handle is carried further over the tooth-sector whereby the slide valve shuts off the air and puts on oil for the fuel oil valves, and then the handle is placed in accordance with the number of revolutions wanted. The operating lever and the handle for the reversing engine are all that have to be moved by the engineer on watch when changing.

Oil Distribution. — The fuel pumps carry the oil to a common pressure pipe and from this it goes through distributors to the fuel valves of the various cylinders. Regarding this manner of distributing the fuel there has been great doubt expressed by the technical profession whether it is correct or not, as most Diesel motor manufacturers either use one fuel pump for each cylinder or one for each half engine (half number of cylinders) so as to enable them to cut out the half number of cylinders by stopping only one of these pumps, and it has been said that it was impossible to distribute the oil by means of distributors so that the engines would run with regularity at all numbers of revolutions.

From diagrams taken it was shown that the greatest variation of the indicated mean differential pressure inside the individual cylinders was 1.8 lb., corresponding to 13 i.h.p., and under the passage through the Suez Canal the *Selandia* was running between two steamers so that at times the number of revolutions was only 35 per minute. Notwithstanding this, the engines worked regularly without having to cut out any of the cylinders, as has proven necessary in engines of other makes in order to obtain regularity during small number of revolutions, and it seems, therefore, to be correct to use distributors, as it means simpler construction of fuel pumps and regulating machinery.

Regulator. — The regulator is an "Aspinal," such as is used on steam engines. It works through a lever on a valve, which is placed in the common pressure pipe from the fuel oil pumps, and by pressing the valve down it shuts off the oil supply to the engines. When the number of revolutions passes 150, the regulator acts, and the fuel pumps, which keep working as long as the propeller turns the engine, pump the oil through relief valves placed on the air chambers of the pumps.

It must be remembered that the regulator only works when the sea is so rough that the propeller blades come above water, and it has been proven that this manner of operation is very satisfactory. During the first trip of *Selandia* to Siam the Aspinals worked incessantly for 60 hr. on account of high seas, and the number of revolutions varied from 90 to 150, as the Aspinals open again for the oil when revolutions have fallen below the normal.

In calm sea the regulation in speed is obtained by giving the engines more or less fuel oil, and for helping the regulation the main shaft of each engine has a flywheel about 6 ft. in diameter, weighing approximately 5 tons. This flywheel may also be used in turning the engines. By means of a small motor-driven turning engine a worm on its shaft can be placed in contact so that the worm engages teeth on the perimeter of the flywheel.

Fuel Oil. — The fuel oil first used by *Selandia* was from Roumania and was a dark and heavy oil with a specific gravity of 0.9328 at 15 degrees cent. and viscosity of 1.9 at 80 degrees. Its heat value was 39 000 B.t.u., and the ratio of hydrogen to carbon was 1.6, consequently it was not a very good oil. Nevertheless, the results obtained were satisfactory, as a repeated determination of the oil consumption showed this to be at full speed 0.332 lb. per i.h.p. per hour, including the consumption of the secondary oil engines. This means a daily consumption of 9.8 tons of oil in twenty-four hours, and, with a capacity of fuel oil tanks of 1 000 tons, means that the ship can make a round trip from Europe to Siam and back, or one hundred days' journey, without having to take in fuel and without the fuel occupying any room except the tanks in the double bottom, which are always used in other ships for ballast, thus giving the entire space used in steamships for coal bunkers over to general cargo space.

Crossheads. — The main engines have crossheads working on water-cooled guides, and as pressure lubricating is being used for main engines, as well as for secondary engines, all these are constructed with closed bases, and oil-tight doors, so as to allow inspection of crossheads, cranks and main bearings; and in order to give regularity, the cranks of the two half parts of each engine are set at an angle of 90 degrees.

Lubrication. — The lubricating oil is pumped by the lubricating pump through the main bearings, then carried through a boring in the crank arm to the crank itself, and further, through

the hollow crank rod and piston rod to the piston, the bottom of which is double. After having cooled the piston it goes through another boring in the piston rod and through a pipe down over the guide planes of the crosshead and to the base frame, from where it is carried to a main lubricating oil tank placed in the double bottom of the ship, where there is one under each engine which holds 2 tons of oil. The total amount of oil circulated is about 20 tons. To the same tanks is led the return oil from the secondary engines, which are lubricated in the same manner. The pistons are lubricated through the automatic Mollerup lubricator, which is driven from the horizontal steering shaft. It will be seen that the work of the engine crew, as regards lubrication, etc., is an absolute minimum.

Lubricating Pumps. — The lubricating pumps consist of two motor-driven double-acting two-cylinder plunger pumps, and each of these is sufficient to furnish the two main engines and the two secondary engines with lubricant, so that the other can always be kept in reserve. They work against a pressure of 15 to 20 lb. The suction pipe is carried to the bottom of the tanks, and after having passed the pump, the oil goes through a filter and a cooler so as to be further cooled before going to the engine. The lubricant used is a cheap, clean mineral oil of viscosity 5 at 50 degrees cent. The pressure lubrication allows the use of a cheap mineral oil, as the large quantities pumped through the engine exclude the possibility of too thin an oil film and a consequent warming of bearings and wear.

Dynamo. — Directly connected to the shafts of the secondary engines there is a dynamo and a secondary air compressor for each engine. The dynamo is of 226 volts and 710 amperes and serves current to all motors on the ship and to the lighting and the wireless telegraph, but for the lighting system the voltage is cut to 110 volts through a transformer.

Secondary Compressors. — The secondary compressors, coupled directly to the secondary engines, compress the air in three stages to 300 lb., and they have a capacity of 14 cu. ft. compressed air each per minute, and consume when working with full open suction valves 150 h.p. each. The compressed air is carried to a cooler and from this to the supply tanks, four of which are hung under the deck, and each having a capacity of 120 cu. ft. From these service tanks the air is carried to the main compressors of the main engines and to the air-driven helping engine for starting and reversing the main engines. From the second-stage chamber of the secondary compressors

is a connection to the whistle and the siren, and the pressure here is about 120 lb.

At sea only one of the secondary engines is working, as the load on the generator, when no winches are operating, does not exceed 50 effective h.p., and the compressor, under normal conditions, runs with almost closed valves; consequently, one of the secondary engines is ample to pull both the generator and the compressor. The other secondary engine is then always ready for immediate use and can be started in a few minutes if it should be necessary to stop the one that is working.

Air Supply Tanks. — The four supply tanks already mentioned are so ample in size that the main engines can run about one-half hour by the compressed air in them and yet have full power for maneuvering. A trial at sea showed that when both of the compressors were stopped, the pressure in the supply tanks fell during sixteen minutes from 300 lb. to 210 lb., yet, even at 150 lb., the engines are fully capable of maneuvering.

Emergency Compressors. — It is to be noted that even in case of accident to both of the secondary engines and the secondary compressors, one cylinder on either of the main engines can, by changing of the exhaust valve and connecting by by-pass to the supply tanks, be used as air compressor, and the engine is then running on seven cylinders and is still capable of developing its full horse-power. As a further assurance, there is a steam-driven compressor which is directly connected to a high-pressure single cylinder steam engine, which gets its steam from an oil-fired donkey boiler, generally used for supplying the ship with steam heat. This compressor has four pistons, all driven from one crank-shaft, and compresses the air in three stages to 900 lb. It is incorporated in the secondary machinery in order to give the most absolute guaranty that the ship will always be able to maneuver as far as compressed-air supply is concerned. This will probably never be used, but it will be seen that all arrangements have been made to assure safety in operation, especially as *Selandia* and *Christian X* were the first real sea-going motor ships.

Exhaust. — The exhaust pipes from the individual cylinders of the main engine are carried to a common exhaust pipe, which is water cooled and hung under the deck. From this pipe the exhaust passes two mufflers for each engine, and the exhaust from the secondary motors is attached to these mufflers. From the mufflers the exhaust is carried through a pipe up through the mizzen mast, which is slotted for the escape of the gases about

50 ft. above the deck. The muffling is so perfect that even in the calmest weather no sound can be heard on the deck from the engines, and the combustion is so complete that no smoke or gases can be seen to escape.

Circulating Pumps. — The circulating pumps for cooling water are motor-driven centrifugals and directly connected to the motor shaft. At full speed each pump gives at 1 600 rev. 50 to 60 tons of cooling water per hour against a head of about 35 lb. One pump is always sufficient for supplying the necessary cooling water.

The cooling water is used for cooling the guide planes of the main engines, the head and cylinder jackets of main and secondary oil engines and in the jackets of the air compressors; also for cooling of pressure bearings, exhaust pipes and lubricating oil.

Sanitation Pumps. — There are two sanitation pumps and general service pumps, which are motor-driven, single-acting plunger pumps, each with three plungers. They are used for pumping water to the deck, for the bathrooms, and can pump water from the sea or from the ship's holds. One piston in each pump is through a suction pipe connected to the cooling water discharge from the main engines and serves to pump warm water to the bathrooms.

Ballast Pump. — The ballast pump is driven by compressed air from the supply tanks. It is a double-acting two-cylinder plunger pump with a capacity of 100 tons per hour.

Main-Fuel Oil Pump. — The fuel oil pump is air-driven and is a two-cylinder piston pump and serves to pump the daily consumption of fuel oil from the main tanks in the double bottom of the ship into two service tanks located in the engine room, each of which holds 6 tons of oil. They are furnished with float and dial so that the engineer can see what oil is on hand. The main object, however, with these service tanks is to separate water and impurities from the oil, and any water and impurities can be drained off from the bottom.

Ice Machine. — The ice machine furnishes refrigeration and ice for the stores and is driven by an 8 h.p. electric motor.

The winches on the deck consist of 12 electric winches, half of them with a capacity of 5 tons and half with $2\frac{1}{2}$ tons on single line.

Steering Gear. — The steering engine is hydraulic-electric, and consists of an electric motor which is running continuously and which is driving a pump with variable stroke which can be

regulated from zero to maximum by the man at the wheel. The pressure liquid from the pumps is distributed to two hydraulic cylinders, the plungers of which act on the rudder quadrant.

Weight. — The weight of all machinery in *Christian X*, including all secondary machinery and donkey boiler, is about 500 tons, or 332 lb. per i.h.p., but in order to be practical for warships the weight per i.h.p. must be reduced to 100 lb., so that there is still a wide field to work on, but since the first very successful trip of the *Selandia*, motor shipbuilding has taken on speed, and during the coming years there will undoubtedly be further developments, and many still better results as regards the use of the Diesel engine as a marine engine.

Economy. — As to the economy, it should be noted that the Diesel engines, for a ship of same size as *Christian X*, would cost about $20 more per i.h.p. than engines and boilers for steam-driven ship of the same size, or a total of about $50 000. To pay for this we have a 1 000-ton extra cargo space, and figuring that only 500 tons of this is made use of, and figuring 3 round trips from Europe to Siam every year, we have 3 000 tons at $5.00 per ton, or $15 000.

The saving in fuel between oil and coal, and the saving in the number of crew on a ship of this size amounts to, per year, $25 000, a total minimum saving per year of $40 000 in profit over and above what would be earned by the steam-driven ship.

Therefore, four fifths of the extra cost of the Diesel engine is earned in the first year, and the balance, $10 000 plus an additional $30 000 profit, is earned in the second year, and after that the annual profit is $40 000. In addition to this the cost of maintenance of the motor machinery is much less than that of steam equipment, and it should be noted that the ship does not need to stop from time to time to take in fuel and that the loading of the fuel itself, sufficient for a 100-day trip, only takes eight to ten hours, with a minimum of work and without the accompanying dirt and dust, such as is the case in loading a vessel with coal.

Final. — The development of the Diesel engine for marine use has had a tendency to give the 2-cycle motor preference, for various reasons: The 4-cycle motor requires double the number of cylinders called for by the two-stroke motor in order to get the same horse-power developed, provided size of cylinder is the same; and it is necessary to have larger engine room for the 4-cycle engines in order to take care of the larger machinery. On the other hand, there are many disadvantages attached to

the use of the 2-cycle engine, — of which I shall only mention such things as the heating of the parts being much greater, and its being, therefore, much more difficult to keep the machinery properly cooled. The 2-cycle engine will also consume more oil, which naturally means increased cost; and a larger supply would have to be carried.

As to the space occupied, the present International Marine Laws are such that the determination of registered tonnage is 32 per cent. of the total volume of the ship, in cases where the machinery space takes at least 13 per cent. of the entire volume. If the machinery space is made less than 13 per cent. of the total volume of the ship, then the registered tonnage is determined by actual measurements, and as the registered tonnage is the deciding factor in determination of port fees, canal fees, etc., it will be seen that the earning capacity of the ship is thus decreased. There may come a day, however, when these regulations for ship measurement will be changed, and when that day comes, the space taken up by the machinery will have to be taken into consideration.

Motor Ship "Monte Penedo." — The *Selandia* and *Christian X* have just made their appearance and have stirred the nations to renewed efforts in the way of motor ship construction, and we already see a new motor ship, the *Monte Penedo*, built by Sulzer Brothers in England, and which is equipped with Sulzer-Diesel engines, which are of the 2-cycle type. The general arrangement and auxiliary machinery are practically the same as that of the 4-cycle type, and the builders have succeeded in getting the machinery down to a total weight of 177 lb. per i.h.p., and as progress will undoubtedly be made on the same lines, and made rapidly, there is no doubt but that shipbuilders will be able to reduce the weight of the machinery accordingly, and we may soon see the navies of the world equipped with Diesel engines, — which at present is absolutely prohibited on account of the heavy weights. Otherwise, the Diesel engine would, of course, be the ideal power for a warship, as it takes up little space, gives hardly any vibration whatever, requires a smaller crew to handle and produces no smoke, thus eliminating one of the means whereby ships are located by the enemy, and as there are no funnels, it gives the large turret guns almost a complete field for operation.

For the detailed information regarding the machinery and its working capabilities on the *Christian X* I am indebted to my friend, Mr. Geo. Erichsen, who was sent as guaranty engineer

for the ship's builders on its first trip, and I desire in conclusion to pay my respects to my friend and classmate, Mr. O. E. Jörgensen, the chief engineer of the Burmeister & Wain establishment in Copenhagen.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1913, for publication in a subsequent number of the JOURNAL.]

REINFORCED CONCRETE HIGHWAY BRIDGES.

By George H. Herrold, Member of the Civil Engineers' Society of St. Paul.

During the past generation activities in means of transportation have been concentrated on the financing and building of railroads. The coming generation will see an equal activity in the financing and construction of highways, and it is possible that private capital may play a large part in this work.

The improvement of highways requires the building of permanent roadways over streams, drainage canals and tracks of steam and electric railroads, and we naturally turn to that excellent structural material, reinforced concrete, as the one best adapted to the construction of permanent highway bridges and culverts. It is especially adapted to this work as it is durable, fireproof, rust proof and expense proof, — for it requires no painting or renewing of floors or repairs, and, in fact, it increases in strength with age, while steel and wood deteriorate, — and for its relatively low cost, for in general the sand, stone or gravel which form the great bulk and weight of the concrete can be secured from nearby pits or quarries, or from the immediate site of the work, by the proper washing of the gravel to remove loam and clay. This also gives employment to local laborers and encourages the operation of local gravel washing and crusher plants.

This may be better illustrated by taking the actual quantities in a given structure; for example, a 60-ft. reinforced concrete girder bridge, 16 ft. roadway and 15 ft. abutments, contains approximately 200 cu. yd. of concrete. Reducing the quantities of the various materials required for the construction of this bridge to tons we have the following:

Cement, 47 tons; steel rods, 12 tons; form lumber, 13 tons; and sand and gravel, 404 tons, or the ratio of the cement, steel and lumber which would have to be hauled to the site of the work is to the weight of the aggregate, which we will assume can be secured at the site of the work, as 1 to 6.

To prove that we have material available and waiting to be used in this form of construction in this great state with its area of 84 000 sq. miles, let us look at the State Geological

reports. We find the entire area is what is known as drift covered, this glacial drift consisting of till, stratified sand and gravel and clay covering the rock to a depth of 100 to 300 ft. Stratified sand and gravel are reported as being found in most of the valleys draining southerly, and rock outcrops in all of the larger river valleys.

Concrete is a material very strong in compression but lacking in tensile strength. Reinforced concrete is a properly proportioned mixture of cement mortar and an aggregate with steel bars or shapes of definite size and number embedded in the concrete at the centroid of the tensile stresses to afford the tensile strength that the plain concrete lacks, so that, in the completed structure, all tensile stresses due to the live and dead load are carried by the steel, while the compression stresses are carried by the concrete alone. This combination of these two materials is made possible by the fact that the expansion and contraction of steel and concrete due to changes in temperature are practically the same.

The designing and building of reinforced concrete bridges require not only a thorough knowledge of the fundamentals, but also practical constructive instinct, together with experience. A poor design, poor material, faulty mixing of good material or poor construction may each contribute to a poor bridge. Where human life is dependent upon the strength of a structure such as a bridge, every safeguard should be thrown around its planning and its building.

Before fixing upon the span length and height of bridge floor, the size of the opening should be determined by a survey of the drainage area and the location of the high-water mark. The foundation material should then be examined to determine the character of the abutment footings and whether grillage would be required or not. Such details as these are usually slighted in highway bridge work, but there is no field in engineering where the motto, "Be Sure You're Right, Then Go Ahead," is more applicable than in any kind of bridge work.

A reinforced concrete bridge should be designed by a competent concrete bridge engineer. The details should receive the same attention as would be given to a steel bridge or building. The construction should be carried out by competent contractors. A cement sidewalk builder is not necessarily qualified to build a reinforced concrete bridge just because he has mixed sand, water and cement together and allowed it to harden, any more than the young man who applied to me for a position on railroad

location was qualified for that line of work; he said that he was a "good hand at camping out."

Reinforced concrete bridge building is a business requiring the best skill and the highest constructive ability. Inspectors should remain on the work constantly. Intermittent inspection of concrete work is valueless. Inspectors must see the actual processes carried out, check the work with the plans as to the dimension of the finished work and the sizes and placing of the reinforcing; see that forms are built to produce the plan dimensions, and that they are properly supported and braced so as not to sag under the weight, or bulge, destroying the straight lines of the finished work. The time for removal of the forms is an important point, and the hardness of the concrete must be determined very carefully. See that bars are properly spliced to transmit the stress one to another. In general, the plans should show where the splicing should be made so that it will not come at point of greatest stress.

The various types of reinforced concrete bridges and culverts adapted to highway work are the reinforced concrete box culvert; the slab floor supported on abutments; beams carrying a reinforced floor; the reinforced through or deck girder; the concrete pile bridge; the reinforced concrete arch and the ribbed arch. A study of the location should be made to determine the best and most economical type to select. For openings up to 8 ft. the reinforced concrete box is the proper type to use, as it is more economical in material than the plain abutments, supporting a slab floor. For spans 8 ft. to 20 ft., use the reinforced slab. For spans 20 ft. to 30 ft., reinforced concrete beams carrying a thin, reinforced slab are probably more economical in material. The actual quantities in the superstructure for a 22 ft. span, 6 beams, 20 ft. roadway, with paneled concrete railing, designed for a live load of 18 tons, the writer recently determined to be as follows:

In the T-beam structure, 24 cu. yd. of concrete; 4 400 lb. of steel; form work, 13 cents a square foot. In the reinforced slab structure, 36 cu. yd. of concrete; 3 500 lb. of steel; form work, 10 cents a square foot.

For spans 30 to 60 ft., with roadway not over 20 ft. in width, the reinforced concrete girder supporting a slab floor is undoubtedly the best design for highway work. It is a massive structure of pleasing appearance and gives the maximum water way for the span length.

For long openings where there is no drift to be contended

Fig. 1. 20-ft. Clear Span, Reinforced Slab Floor, with Concrete Railing.

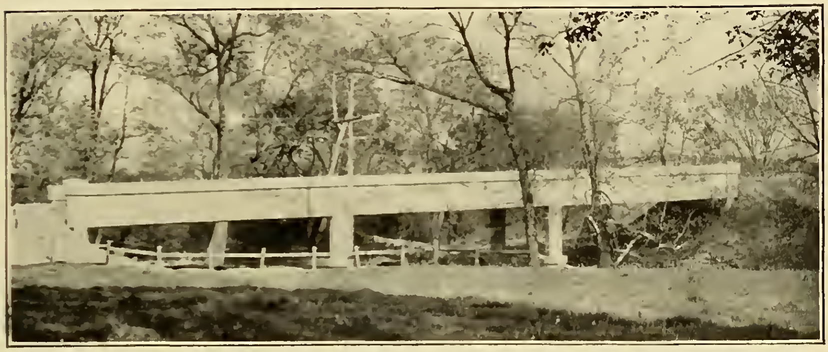


Fig. 2. Reinforced Girder Bridge, built near Springfield, Ill., under supervision of Illinois Highway Commission.

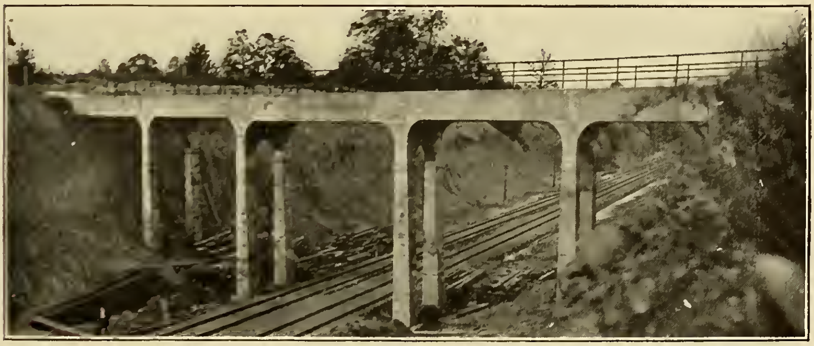


Fig. 3. Reinforced Concrete Trestle, carrying highway over railroad tracks in Indiana, built by the C. C. C. & St. L. Railway Company.

with, or for approaches to spans over a stream or railroad tracks, the reinforced concrete pile bridge with slab floor is very economical in material; in fact, it is a type worthy of more consideration than has been given it for highway work.

Arch construction is a desirable type in crossing deep ravines, but where the head room is low, requiring a flat arch and massive abutments to take the thrust, it is not desirable nor economical on account of the large amount of material required. It should not be used except where there is a stone foundation, as there is danger to its stability from a slight settlement of the abutments. This applies to highway work where utility and cost are the first consideration. For parks and approaches to towns and cities, where cost is not the first consideration, the arch is a very desirable type. Concrete railings should be used on all concrete bridges, as they add to the massive appearance.

It is not the purpose of the writer to take up the theory of design, but he wishes to call attention to one or two points that must be given attention in designing a reinforced concrete bridge. If one considers the tensile stress acting in the reinforcing steel in the bottom of a girder or beam or slab floor, it is plain that there must be a corresponding and opposite stress which is the bond between the concrete and the steel, and this resisting stress must be greater than the tensile stress in the steel to insure the integrity of the structure. For this reason bars that are deformed are better than plain, round or square bars, provided the concrete is tamped to fill the deformations. Also bars that are spaced some distance apart develop more bond resistance than those close together; also small rods are better than large ones within certain limits, as they have a greater frictional surface for the same total cross-sectional area of steel. Actual tests of concrete beams show that the depth of a girder or beam should be limited to between one twentieth and one tenth of the span. The width of the top of a girder would be determined by the compressive stress, and the width of the bottom of the girder by the amount of steel to be embedded in it.

Specifications should cover three classes of bridges for highway work: one to cover main or state highways leading to cities and towns; one for auxiliary roads or feeders to the main highway, and one for cross-country or township roads, used by the settlers in getting to the roads of the other two classes.

The live loads used for designing bridges of these three classes would be a 20-ton, 15-ton and 8- or 10-ton road roller. This would reduce the cost on little-used roads and still permit

bridges of a permanent character to be built, and eliminate the continual annual maintenance cost of temporary bridges.

It would be the opinion of the writer that no reinforced concrete bridges should be erected without first having the plans submitted to some central authority to pass upon them, and that the actual construction should be carried out under an inspector who had passed an examination showing that he is competent to act as an inspector of reinforced concrete construction.

The writer recently attended a bridge letting in an adjoining state. The experience is worthy of record, and replete with food for thought. Plans and proposals for ten reinforced concrete bridges, with alternate plans for steel at four of the sites, were advertised for by the county commissioners. The specifications gave the span length, height and width of roadway, and called for a loading of 200 lb. per square foot, or a 20-ton road roller. Bidders were requested to visit the site of each bridge and submit a plan and a lump sum bid for the structure. On the appointed day, fifteen bidders appeared at the county seat and submitted their plans and proposals before the hour of closing bids, 6 P.M. They were then informed that the bids would be opened next day. I do not wish to impugn for a moment the motive of these honest commissioners, but the visitors had the privilege of buying "eats, smokes and liquid refreshments" during the evening. The next morning the bids were opened; approximately 125 plans were submitted to those five honest farmers, who, assisted by the county surveyor, proceeded to analyze the plans and tabulate the bids. It was finally decided to let the concrete bridges to a local cement street paver, and the steel bridges to a relative of one of the county officers. The commissioners evidently decided that, as they knew nothing about the relative value of the plans, they would take a chance on men whom they knew, regardless of other considerations. The lowest bidder was informed that they did not like his plans. The bids ranged about as follows: a 24-ft. span reinforced concrete bridge, \$550 to \$1 228; a 40-ft. span, \$835 to \$2 980; a 60-ft. span, \$1 175 to \$3 980. A number of the bidders submitted plans furnished by manufacturers of reinforcing. Some of the plans were excellent, and others were like the present-day millinery, fearfully and wonderfully designed. One bidder told me that a live load of 80 lb. to the square foot was good enough for designing any bridge. Another handed me his card; it read, "John Doe, Manufacturer of Cement Blocks,"

Fig. 6. Reinforced Concrete Arch built on the Mississippi River Boulevard, St. Paul., under supervision of the Superintendent of Parks.

Fig. 4. Reinforced Concrete Trestle over ravine near Duluth. Shows a very handsome form of concrete railing. Built under the supervision of the County Bridge Engineer.

Fig. 5. Reinforced Concrete Arch, 55-ft. Span, built in Montgomery County, Maryland, under supervision of State Highway Commission.

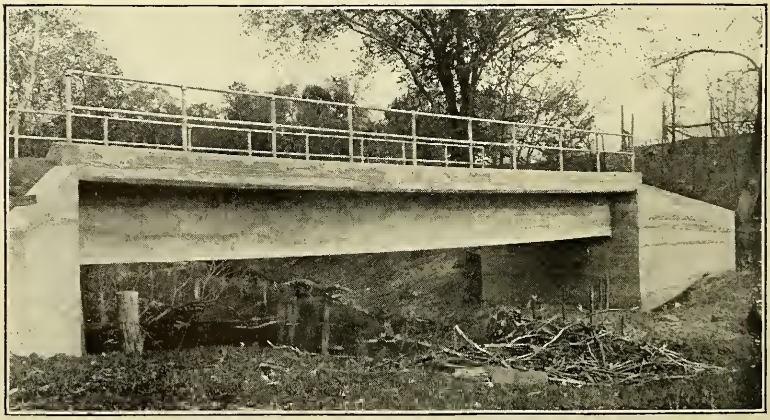


Fig. 7. Built in Minnesota. 60-ft. Clear Span. 60-in. girders with 10-in. slab. Wheel guards 12-in., with galvanized gas pipe rail (wheel guard reinforced).

and written across the card in ink, for this especial occasion, "and Reinforced Concrete Bridge Engineer." That there is a necessity for some central authority to take up and pass upon reinforced concrete bridge work in that locality is evident.

The accompanying views, Fig. 1 to 6, are illustrative of the types of bridges mentioned, and represent good practice for ordinary highway work. Fig. 7, which is a 60-ft. span, reinforced concrete beam or deck girder bridge, is a poor type of bridge for its location, is poorly constructed and sags in the center. If a through girder bridge had been built it would have increased the head-room 60 in.; and there is indication from the amount of brush and rubbish that more head-room might be required. If additional room is not required then the through girder type could have been built considerably lower, lessening quantities in the abutment and bringing the roadway of the bridge down nearer the level of the roadway on each side, instead of requiring one to drive up-grade, as at present, to get on to the bridge.

[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1913, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER, "RAILROAD VALUATION."

(VOLUME XLIX, PAGE 204, DECEMBER, 1912.)

MR. F. G. JONAH (Member of the Engineers' Club of St. Louis). — The writer desires to offer a few criticisms of the paper by D. F. Jurgensen. The views expressed by Mr. Jurgensen are so widely at variance with the expressed opinion of engineers generally that it is well to call attention to them.

Mr. Jurgensen proposes in his paper to demonstrate that the methods adopted by the Master in Shepard *v.* Northern Pacific Railway Company have "no basis in law or fact." The writer fails to see where he demonstrated anything of the kind, and, as this case is shortly to be reviewed by the Supreme Court of the United States, we can safely await its decision and not argue this question at this time.

On the subject of franchises, the idea is advanced that they constitute no element of value, because they have been granted by the public. The railroads nevertheless pay taxes upon them as values, and consequently should be permitted to earn upon their value.

On the subject of right of way and land, Mr. Jurgensen says:

> "If a railroad company is entitled to earn a return upon the real value of its property, and if such real value is to be taken as of the present time, it shares in the general prosperity of the country and gets the benefit of any advance in land values."

How can a railroad get the benefit of the enhanced value of its property, unless it is permitted to earn on the enhanced value? The right of way and property of a railroad can only be used for the specific purpose for which they are acquired; the railroad cannot sell them, but must pay taxes on the enhanced values, and is, therefore, worse off than before, if such increase in right-of-way value is not added to the total value of property on which rates should be based.

Under the head of "Imaginary Items," Mr. Jurgensen places —

Interest during construction.

Contingencies.

Engineering.

As to interest during construction, Mr. Jurgensen argues that if we "conceive a road to be constructed in one day, but one day's interest will be incurred. If the construction occupies a century, the interest charges will be very heavy."

It is not necessary to conceive any absurdities about railroad construction. The historical records are extant as to how long it took to build each piece of railway, each system or division of systems in this country, and engineers can estimate with reasonable accuracy how long it would take to build a new line, or reproduce an old one.

The men who finance railway projects do not class interest during construction as an imaginary item.

How Mr. Jurgensen can place engineering as an imaginary item is certainly surprising, coming from an engineer.

It is item *No. 1* in the Interstate Commerce Commission classification of construction accounts, which accounts also provide for interest during construction, and for law expenses, which Mr. Jurgensen classes as "fictitious and illusive."

The writer believes that the profession generally will be guided by the Interstate Commerce Commission classification, and continue to make their estimates accordingly, notwithstanding Mr. Jurgensen's paper.

OBITUARY.

Horace Ebenezer Horton.

MEMBER OF THE CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

HORACE E. HORTON, a member of this Society for over twenty years, died on July 29, last, at his home in Chicago, at what should have been for him the early age of sixty-nine years. Coming of Puritan stock, with long-lived ancestors, a magnificent physique which he had never deteriorated by foolish living, he could have expected twenty-five years longer lease of life, but for one of those diseases before which the skill of the physician becomes a mockery.

Mr. Horton was born on a farm just out of the village of Norway, Herkimer County, N. Y., on December 20, 1843. His mother's family had long been natives of Connecticut. His father's family, for many generations, had lived on the eastern end of Long Island. Not many years ago, one of the writers heard from Mr. Horton an account of a recent visit he had made among his father's people, still located on Long Island, and remembers distinctly with what pleasure he recounted his meeting the older members, all of whom were in their eighties and nineties.

Mr. Horton moved with his parents, when he was thirteen years of age, to Rochester, Minn., where he attended the public school, and where he continued to have his residence for the following thirty-three years. He was sent East to the Fairfield Seminary, in Herkimer County, New York, to complete his school education, and during some two years spent in this institution he received whatever technical training he had, other than that of practical experience. It would be very interesting to know just what character of instruction he received at that time, which was to be the basis for his future success as an engineer. Probably the meagerness of it would be both astonishing and humiliating to some of the more recent additions to the profession, if supplemented by a comparison of results. Mr. Horton was a representative of a class which probably every generation thinks exceptional; men who — from the standpoint of to-day, provided with but poor equipment — have achieved even what we of to-day consider large things. The lesson is easy to read, if

Horace E. Horton.

not to follow, — the man whose education stops with his degree is beaten before he starts; there are God-given qualities which will surmount many obstacles; that diligence and perseverance on our part are the determining elements, rather than the early opportunities of education.

Mr. Horton returned to Rochester when he was about twenty years of age, and spent the following three years in finding himself, — doing some farm work, some surveying and some railroad location work. Probably his first real entrance into engineering was when he was twenty-three years of age, at which time he designed and built, as a contractor, a timber arch bridge, in the village of Oronoco, Minn., of 186 ft. span, and which was 60 ft. high above the water. With this as a starting-point, he was duly launched upon his life-work. For the following twenty-three years he had his headquarters at Rochester, and built up an extended business in the designing and erection of highway bridges throughout a considerable area of the Northwest. During this time he also developed some skill as an architect, designing a number of public buildings as well as private residences.

Up to the year 1889 he had conducted his business as a bridge contractor, independently of any shop. He had begun business in the days of timber bridges, had passed through the combination stage, and had seen the metal bridge become the universal one. Recognizing that he must either become a manufacturer, or lose his identity in his business, in 1889 he moved to Chicago, and in conjunction with others started the Chicago Bridge and Iron Company, of which he was the president and manager until the destruction of the plant by fire in 1897. At that time Mr. Horton purchased all of the outside stock in the company, rebuilt the plant, and operated it thereafter in his own name, as the proprietor of the Chicago Bridge and Iron Works.

Mr. Horton's great ability was as an engineer and as a contractor, rather than as a manufacturer. The interminable detail work of the latter annoyed him, and it was a great pleasure to him in the later years when he could turn over much of this to his eldest son. It was with real pleasure he would reply, "Well, now, you will have to see the general manager about that; I do not have anything to say any longer in that line."

As an engineer, Mr. Horton was always progressive. When the combination of wood and iron became economical, he was prepared to use them to produce rational designs therewith. When the virtue of cantilever constructions for certain condi-

tions was pointed out, he was ready to utilize them. A man of the most thorough common-sense, he utilized this in the design of his structures, which were proportioned to the service they were expected to give rather than to some letter of a specification. At a time, twenty-five years ago, when communicating bridges were in demand by cities located on the banks of the Upper Mississippi River, where the conditions necessitated long and high structures, with but a very limited amount of money available, he designed and built bridges which some people denominated "spider-webs," but which were strictly adapted to their service, and which have continued all these years to properly take care of the business. They were very light, and relatively inexpensive structures, but they showed the skill of the designer, and the adaptation of means to ends. There was no metal wasted, but every pound was used to the best advantage.

Perhaps Mr. Horton was best known to many people through his improvements in elevated water-tank design and construction. In 1894 he brought out a design for a steel water-tank supported on steel columns, the tank having a hemispherical bottom, and the columns connecting directly to the sides of the tank. Prior to this, while the steel tank on steel columns had been used quite largely, its general adoption had been prevented by the expense incident to the method of construction. The tanks had generally been flat-bottomed, supported on the columns by means of heavy floor-beams and closely spaced joists, while there had been some instances of tanks with conical bottoms, and also with segmental bottoms, both of these forms necessitating materially more metal, as well as more expensive shop work, than did the full hemispherical bottom produced by Mr. Horton. The method he adopted, too, for dishing these bottom plates, was novel and inexpensive. The result of these improvements, as well as of the energy and skill with which the sale of the structures was promoted by him, has been the general adoption of this form of elevated tank, and examples thereof are to be found in all portions of this country, many of which are the product of his shop.

Mr. Horton's skill and courage as a contractor fully equaled and perhaps surpassed his ability as an engineer. In his case, the engineer and contractor were one. Being satisfied that a certain thing was feasible, he had the courage and skill both as an engineer and as a contractor to carry it out. If the state of the art did not provide the tools and facilities to suit him, he promptly devised others. He had a large amount of ingenuity,

amounting to the true inventive instinct, and his shops contain many evidences thereof. So far as known, however, he never patented any improvement he made.

As a man, Mr. Horton had a disposition which comported well with his body. He was a warm-hearted man, gifted with a keen sense of humor, somewhat quick of temper, but always desirous of being fair and just, so that the men who knew him best loved him and delighted in his company. He thoroughly enjoyed meeting with his professional friends, and wherever he was at such times, he was generally the center of a circle.

Mr. Horton joined this Society in 1887. His removal to Chicago made it impossible for him to be present at many of the meetings, but he always had a very kindly feeling for his old friends in the Northwest. He became a member of the American Society of Civil Engineers in 1882, and was a director from 1907 to 1909. He joined the Western Society of Engineers in 1881, and was its president in 1895. He was not a large contributor to the literature of these societies, having contributed but two papers to the Western Society. His articles, however, as well as his discussions of papers of others, always bore evidence of his sanity of thought, and of his ability to grasp the real essential elements of the question under consideration.

Mr. Horton was married, in 1871, to Miss Emma Babcock, of Waupun, Wis. She survives him, with their five children, George T. Horton, Mrs. K. Koessler and Horace B. Horton, of Chicago; Mrs. R. H. Murray and Hiram T. Horton, of Greenville, Pa.

C. F. Loweth.
W. W. Curtis.
C. J. A. Morris.
W. L. Darling.
Oscar Claussen.

OBITUARY.

Edwin Ellis Woodman.

Member of the Civil Engineers' Society of St. Paul.

Edwin Ellis Woodman, past president of this Society, died August 29, 1912, at his summer home at Shell Lake, Wis.

He was born at St. Louis, Mo., June 1, 1838, of New England parentage. His father died in St. Louis when Edwin was about fifteen years of age. He attended the grammar schools in St. Louis until he was fifteen years of age, when his mother removed to Monroe, Wis., where he completed his grade and high-school studies. While attending school in Monroe he acquired a taste for engineering from his friend and patron, Mr. J. T. Dodge, who was at that time, and for many years thereafter, one of the foremost engineers in the West. Under the care and supervision of Mr. Dodge, he laid the foundation of his engineering profession. In order to acquire a better knowledge of higher mathematics he attended the University of Wisconsin for a time, but lack of sufficient funds to complete the required course compelled him to leave the University. He then took up teaching in the hope of later completing his university course, but soon after the Civil War broke out and he enlisted in September, 1861; was commissioned captain of Company B, 13th Wisconsin Volunteer Infantry, and served the full term of his enlistment, three years, with credit to himself and benefit to his country. He never returned to his classes in the University, but in the year 1880 the University of Wisconsin, in recognition of his ability as an engineer, conferred upon him the degree of Civil Engineer.

After the war closed he returned to Monroe, Wis., and for a time was principal of the high school at that place. He then took up and followed his chosen profession until the panic of 1873 caused a discontinuance of all railroad work in the West. For six years thereafter he edited and published the Baraboo *Republic*, a weekly paper. This paper was, during the time he was its editor, considered one of the strongest, if not the strongest, editorially, of any weekly paper published in the state of Wisconsin.

Edwin E. Woodman.

He was a graceful, fluent and forceful speaker, and, as a writer, was the master of a most lucid and captivating style. His writing and public addresses soon placed him in the front rank among the strong men of his state. He was elected and served a term as senator from his senatorial district and was strongly endorsed for nomination to Congress.

When, in 1881, railroad construction again required experienced engineers, Captain Woodman returned to the work and continued in the service of the Chicago & North Western Railway Company, until elected secretary of the Chicago, St. Paul, Minneapolis & Omaha Railway Company, in June, 1884. He held that office until failing health compelled him to resign in October, 1907. He never regained his health and passed away in August last.

His most notable engineering works were the construction of two bridges over the Mississippi River for the Chicago, Milwaukee & St. Paul Railway Company; one at St. Paul and one at Hastings, and the construction of tunnel No. 3 on the Chicago & North Western Railway Company's line between Sparta and Elroy, Wis. His last engineering work was in the spring prior to his election as secretary of the Chicago, St. Paul, Minneapolis & Omaha Railway Company, being the location of a line for the Chicago & North Western Railway Company from De Kalb to Spring Valley in Illinois.

Capt. Edwin Ellis Woodman was a man of the very highest character, with the highest ideals, and of rigid honesty. He was an inborn gentleman, at all times and under all circumstances courteous alike to all. Rich or poor, educated or uneducated, all were treated the same by him. He was a skillful engineer, as his many works still show, but all in all he was a poet. He had in the highest degree the poetic nature, as all must feel who have read his writings. While he was a man of affairs always engaged in active business, his greatest delight was in his home, his friends and his books. Few men are endowed with so great capacity for the enjoyment of literature.

Captain Woodman had no enemies. All who knew him, from janitor to president of the great system he so faithfully served, were his friends.

ASSOCIATION OF ENGINEERING SOCIETIES.

Minutes of Meeting of Board of Managers, January 15, 1913, in New York City.

There were present the Chairman, Gardner S. Williams, representing the Detroit Engineering Society; Messrs. Dexter Brackett, Charles W. Sherman, Harrison P. Eddy, Henry F. Bryant, Edwin R. Olin, representing the Boston Society of Civil Engineers; also Fred. Brooks, Secretary. These gentlemen held powers of attorney for voting at this meeting from Messrs. S. E. Tinkham, A. T. Safford and J. R. Worcester, of the Boston Society of Civil Engineers; A. R. Starkey, of the Civil Engineers' Society of St. Paul; Loren E. Hunt, of the Technical Society of the Pacific Coast; T. H. Hinchman, Jr., of the Detroit Engineering Society; and D. C. Henny and F. A. Naramore, of the Oregon Society of Engineers.

The chairman submitted the following report:

Report of the Chairman of the Board of Managers.

January 15, 1913.

To the Board of Managers
of the Association of Engineering Societies:

Gentlemen, — Your Chairman was first elected to the office in 1907, and began service in 1908, at which time the Association consisted of nine societies, with 20 members on the Board of Managers. During 1908 both the Toledo and Cleveland societies severed their connections with the Association, and the Utah and Milwaukee societies united with it, leaving the Society membership as before, and that of the Board at 18, in the beginning of 1909. An increase in membership of the Boston Society during 1909 added one to the Board, making the membership 19 in 1910. A further increase in the same society brought it up to 20 in the beginning of 1911. During 1911 the Milwaukee Society withdrew and the Oregon Society united, holding the membership of the Board at 20 for the beginning of 1912, in spite of a loss of one member by decrease in membership of the Technical Society of the Pacific Coast.

A further growth of the Boston Society and an increase of the Detroit, Oregon and Louisiana societies has now brought the allotted membership of the Board to 23, though there are two

members as yet unappointed, representing 9 societies, and indicating a larger membership in the Association than ever before.

A contract has just been entered into, covering the advertising for the Association's JOURNAL, which it is thought will add to the attractiveness of participation in the Association by decreasing the Society assessments.

The present allotted membership of the Board is —

Engineers' Club of St. Louis	4
Boston Society of Civil Engineers	8
Civil Engineers' Society of St. Paul	1
Montana Society of Engineers	1
Technical Society of the Pacific Coast	1
Detroit Engineering Society	3
Louisiana Engineering Society	2
Utah Society of Engineers	1
Oregon Society of Engineers	2
Total	23

By the death of Mr. George A. Kimball, of the Boston Society of Civil Engineers, which occurred December 3, 1912, the Board lost one of its most valuable and interested members. Mr. Kimball was serving on the Auditing Committee of the Board at the time of his death, and the report of the committee prepared by his associates shows the following condition of the finances of the Association January 1, 1913:

ASSETS AND LIABILITIES — APPROXIMATE.

Assets.

Bank balance	$5,062.10
Cash on hand	306.46
Deposit with Boston postmaster	10.01
Due from Louisiana Engineering Society	219.12
Due from all other societies	26.92
	$5,624.61

Liabilities.

Secretary's salary, from November 1, 1907, to January 1, 1913	$4,650.00
Samuel Usher, printer	328.45
Hub Engraving Company	38.14
	$5,016.59
Balance	608.02
	$5,624.61

The purpose of the Association of Engineering Societies being primarily "to secure the joint publication of the papers and transactions of the participating Societies," it is essentially a business enterprise, and is now twenty-two years old, its articles of association having been adopted December 4, 1880. Of the four societies that formed the original group, two — Boston and St. Louis — still remain in the Association.

The growth of the national societies, together with the inclination of local organizations to develop along social lines, not to mention the increased circulation of the engineering journals, have tended to restrict the growth of the Association, but as there are still nine societies that find advantage in the organization, it seems worthy of continuance, and with the development of its advertising by an aggressive campaign, as now proposed, there seems good reason to believe that the organization has before it a long period of usefulness. Certainly there are manifold advantages to the practicing engineer in having the best of the output of the several societies in a single binding, appearing at regular periods rather than scattered through a number of miscellaneous publications, many of which are rarely seen outside of the members of the individual society.

All of which is respectfully submitted,

Gardner S. Williams, *Chairman.*

It was moved, seconded and voted, that the report of the Auditors be adopted, and that the thanks of the Board of Managers be extended to them.

After discussion of the subject of advertising, Mr. L. R. Hudson, Advertising Manager, was invited in and took part in the discussion. After Mr. Hudson had withdrawn, it was moved, seconded and voted unanimously that the abrogation of Article 26 of the Rules of the Board of Managers and the re-numbering of the other articles be recommended to letter-ballot.

It was then

Resolved, that the Chairman and Secretary be authorized to enter into a contract with Mr. L. R. Hudson as Advertising Manager on the lines which have been discussed at the meeting of the Board on January 15, 1913, subject to the abrogation of existing Rule 26 by the Board of Managers by letter-ballot.

The matter of the count of members in societies receiving the Journal was brought to the attention of the Board and it was unanimously voted that the following rule proposed by the

Secretary for addition to the Rules of the Board be submitted to letter-ballot.

In case the numbers upon the mailing lists for the two months next succeeding the rendering of a quarterly bill, that is to say, for the JOURNALS of January and February, of April and May, of July and August, or of October and November, should differ from the numbers charged to any Society upon that quarterly bill, a corresponding allowance shall be made in connection with the next following quarterly assessment, *Provided* that demand therefor be made by either party, the Society or the Association, so as to be received by the secretary of the other party within three weeks of the time when the last mailing list, viz., for February, May, August or November JOURNAL, is mailed by the Secretary of the Association to the address of the Secretary of the Society.

Adjourned.

FRED. BROOKS, *Secretary.*

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. L. MARCH, 1913. NO. 3.

RAILROAD ACCIDENTS: THEIR CAUSES AND REMEDY.

BY D. F. JURGENSEN, MEMBER OF THE CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

BEFORE the value of any remedial measure can be determined for railroad accidents and their resulting casualties, the principal causes of accidents must be ascertained. The Interstate Commerce and many of the state commissions have for some time past conducted investigations resulting in a large amount of information, from which reliable deductions may be drawn concerning the causes of railroad accidents. Accident bulletins of the Interstate Commerce Commission, Nos. 42 and 43, are the latest issues available, and cover the six months period between October, 1911, and March, 1912, inclusive. The conditions described are, generally speaking, typical. It is found that 7 249 train accidents occurred on the interstate steam railroads in the United States during that period, resulting in 447 deaths and 8 383 injuries to persons.

ACCIDENTS CAN BE CLASSIFIED.

It is apparent from a study of the causes to which these mishaps are attributed, they may first be classified under two heads, to wit, preventable and non-preventable.

Preventable Accidents.

Under this head should be placed all accidents caused by collisions, spread rails, soft track, bad ties, irregular track and negligence of employees. The responsibility for them can be directly placed; they are attributable to carelessness, human fallibility, false economy or failure to provide safe means on the

part of the companies. Thus in each case some duty has been neglected because of which the casualty occurred.

Non-Preventable Accidents.

Non-preventable accidents are those caused by latent defects of equipment, broken rails, unforeseen and malicious obstructions on track, etc., the responsibility for which cannot be directly placed.

RAILROAD ACCIDENTS ON INTERSTATE STEAM RAILWAYS IN THE UNITED STATES.

October, 1911, to March, 1912, inclusive.

Causes.	Number.	Persons.	
		Killed.	Injured.
PREVENTABLE:			
Collisions	3 100	267	4 804
Spread rails	145	4	167
Soft track	188	3	93
Bad ties	30	0	17
Irregular track	258	6	327
Misc. roadway defects	168	8	204
Negligence of employees	214	7	224
Totals	4 103	295	5 836
NON-PREVENTABLE:			
Defects of equipment	1 981	38	698
Broken rails	277	22	768
Unforeseen obstructions on track	214	35	273
Malicious obstructions on track	33	6	127
Miscellaneous	639	50	665
Sun kink	2	1	16
Totals	3 146	152	2 547
Grand totals	7 249	447	8 383

Under the above-mentioned classification, it is shown that preventable accidents are responsible for

4 103 or 56.6 per cent. of all the mishaps,
295 ,, 66.0 per cent. ,, ,, ,, deaths,
5 836 ,, 69.6 per cent. ,, ,, ,, injuries,
6 131 ,, 69.4 per cent. ,, ,, ,, casualties.

Collisions the Salient Feature.

Collisions alone are found to be responsible for

3 100 or 75.5 per cent. of the preventable accidents, and 42.7 per cent. of all accidents.

267 or 90.5 per cent. of the deaths from preventable accidents, and 59.7 per cent. of deaths from all accidents.

4 804 or 82.3 per cent. of the injuries from preventable accidents, and 57.3 per cent. of injuries from all accidents.

5 071 or 82.7 per cent. of the casualties from preventable accidents and 57.4 per cent. of casualties from all accidents.

Collisions have been particularly conspicuous among railroad casualties during the past year, and early relief therefrom must be secured to the public, which is demanding the safe service to which it is justly entitled. If this single cause can be eliminated, an important step will have been taken toward making railroad travel safer.

Collisions are Inexcusable.

Of all classes of railroad accidents, collisions appear to be the least excusable. From a study of the rules, regulations and other safeguards thrown around operation of trains by the companies, it is impossible to foresee how a collision could occur if strict compliance therewith be rigidly observed, but they do occur with appalling frequency and are the direct cause of a majority of the casualties.

Cause of Collisions.

It is difficult to see any value in a rule which is not enforced; if, therefore, we find that each collision resulted from a failure by some one to observe a rule made to prevent such an occurrence, our problem is simplified to finding some means for the establishment and enforcement of proper rules, for there is no industry in existence more dependent upon the human element for its safe operation than is a railway. In none of the ordinary walks of life, generally, are employees so well compensated for their services. Their hours of labor and rest have also been regulated by legislation to their advantage. They may and should be held to a high degree of efficiency.

Responsibility for Non-Observance of Rules Disputed.

There is apparently a sharp division of opinion on this score, between the managers and general officers who formulate the rules and the employees who are required to obey them. It is a familiar claim that employees are at times expected to

violate written rules, and if the required operations are to be conducted within the time allowed, such violations are unavoidable. This is denied by the officers, who claim that observance of the rules, though earnestly desired by them, is impossible of enforcement, because of the negligence of their employees, and that the fault for such violations is chargeable to the individual employee.

State should Assert Its Authority.

Without attempting to say which of these contentions is true, or whether the truth lies between them, the mere fact that the rules are violated, and that each class asserts that their observance is prevented by the activities of the other class, demonstrates the necessity that the state, more powerful than either, and representing the public, must in some manner assert its authority and secure both the establishment and the observance of proper methods of operation.

Steel Cars v. *Wooden Cars.*

In our effort to eliminate the causes of collisions, we should confine ourselves strictly to questions which are pertinent to the problem. In my judgment, the wreck-resisting qualities of steel and wooden cars should not enter into consideration, because to anticipate the continuation of this lamentable feature of railroad operation with a view toward the construction of wreck-proof cars and equipment would be equivalent to a suggestion to the public that they should not expect to obtain satisfactory relief from preventable railroad accidents.

Automatic Control of Trains.

Automatic mechanical devices for controlling train operation have been suggested as being the only possible means for checkmating collisions on the railways in this country.

The necessity for automatic control of trains is not established until we have exhausted all means for prevention of errors in train operation now at our command. Some justification will then exist for seeking other fields for a remedy.

The fact that European managers do not consider such mechanical means essential for safe operation of trains should induce us to exercise caution in recommending measures of this character for adoption. It might be preferable to emulate the methods of our foreign neighbors, whose enviable record of comparative freedom from preventable accidents in railroad opera-

tion has attracted wide comment and approval, even in our own country.

Automatic Train Control Secondary to Signal Systems.

The automatic train control device, if its utility could be established, would at the very best be only an auxiliary to and of secondary importance to the signal systems, and past experiences have proven that practices not essential to the safe operation of trains are, as a general rule, not given the careful attention that the primary measures receive.

Automatic Train Control v. Automatic Coupler.

Notwithstanding that the inventive genius of man has not yet been able to devise an automatic train control device that will work with absolute precision under all climatic and other conditions arising in train operation, arguments have been advanced to the effect that legislation should be enacted making the adoption of such means compulsory on the part of the railway companies within a limited period of time; the point in view being that such action would tend to spur the railway companies into hastening the perfection of such means. Legislation resulting in the adoption of the automatic coupler and other safety appliances, pertaining to cars and locomotives, is cited as an example of what may be accomplished in this direction by the passage of such laws. However, this legislation requiring the railway companies to adopt the automatic coupler was not made effective until many years after the device had been perfected. Its practicability, absolute reliability and worth had been established beyond a question of doubt by severe service tests in actual railroad practice, and it had already been adopted by many of the leading railroad companies in this country. In this regard, there is positively no similarity between the two propositions. The elimination of the old type "link and pin coupler" for the automatic type presented an entirely different problem from the removal of the human equation from train operation. The former concerned the employee's safety while in the act of performing his prescribed duties, while the problem in hand contemplates largely the passengers' safety from the employee's failure or error in performing his prescribed duties.

Danger in Automatic Control of Trains.

Except perhaps in a very few conceivable special cases, it is a question whether grave danger does not lurk in the introduction of a mechanical means that tends to make an automaton

of a railway employee. This device is likely to make the employee careless of the responsibilities which he has assumed. It may cause him to feel that he is a mere supernumerary who has been practically relieved of responsibility in the handling and control of the train, vigilance over track, signals, flags, and in fact will, to a certain extent, encourage the omission of many of the duties and requirements so essential and necessary to insure the maximum of safety in train operation.

Automatic Train Control will Shift Responsibility.

The automatic train control device might shift the responsibility of safe train operation from the high-grade and long-experienced engineman or train operator to the less experienced maintainer of mechanical devices. The successful working of any piece of mechanism is solely dependent at all times on the hand and mind creating it, so it must need follow if the human agency fails, either directly as in the first instance or indirectly as in the second case, a calamity would result.

Mechanical Precision v. *Human Precision.*

Even if we were to realize the ideal automatic mechanical control of trains, it would still be extremely doubtful if such beneficial results could be obtained from the automaton as would be possible from the best efforts of the human agency, because it has been well demonstrated in the past that the skill of the human hand is capable of producing results which the most accurate mechinery cannot accomplish. No system of mechanical safeguards can be devised that will dispense entirely with human responsibility. Man's genius, with all its vast accomplishments in mechanical perfection, has not yet succeeded in developing the "fool-proof" machine, but in every operation there appears at some point the dominating influence of the human mind. Let it relax or waver for an instant and all mechanical perfection is at naught.

American Railways Superior in Mechanical Equipment.

No railways are better equipped with mechanical devices for safeguarding human life than are the railways of this country. Cars and locomotives of the most modern construction, equipped with air brakes of the most efficient design, are in general use. Highly perfected automatic signal systems, designed to preclude the possibility of collisions, are in use on many lines. Their use is being extended, although not so rapidly as might be. Yet, with all these mechanical measures, lives are snuffed

out by the score, because some man failed to perform his duty. With all our perfection in this direction, it begins to appear as though we are encouraging carelessness among employees through over-confidence in mechanical perfection.

Investigations of Collisions.

A notable feature in practically every report of collisions is the recital that one or several employees failed to do something which they should have done, and if they had obeyed the rules of the company, the collision and resulting casualties would not have occurred. In this regard, there is a marked contrast in sensibility to duty and appreciation of responsibility to society between the railway employees of this country and those of European railways. Whenever the European railway employee fails in performing his prescribed duty in train operation, and his failure of duty results in death or injury to persons, he is held accountable to the state, and it is an interesting fact that there are even less fatalities in connection with the operation of railways in Germany than with that of the agricultural pursuits of that country.

American Employee v. European Employee.

It is doing the American employee an injustice to contend that he is inferior, mentally and physically, to his European brother and, therefore, that it is necessary to devise mechanical means to perform the services to which society is entitled and which the employee is in duty obligated to render. If it is possible for the European railway manager, the American manufacturer, business man, contractor, and the government, to obtain absolute reliability and precision from their employees, it ought not to be impossible for the American railway companies to get the same attention to duty and precision from their employees.

Railway Employees should be Sensible of their Debt to Society.

The railway employee should understand that a railway is a quasi-public corporation, and that when he accepts employment with it, he becomes a quasi-public servant and owes the same duty and responsibility to society as the company that employs him.

Remedy should be Devised for Fallibility in Railway Employees.

Since the foregoing statistics show that human fallibility is responsible for 59.7 per cent. of the deaths and 57.4 per cent. of

the casualties, resulting from all accidents, for the period under consideration, it is apparent that serious investigation must be made to find an effective remedy. This is especially true since it has been demonstrated that it is not impossible to obtain reliability and precision from such employees in other countries and from employees in the other industries of this country.

Relations between Railway Managers and Employees.

There should be closer working relations between the managers and employees of railways for the purpose of encouraging open and free discussion on the subject of safety. The problem of making men trustworthy and dependable, if approached in the right direction, will not be found the hopeless task it is often assumed to be. Some of the railway companies have already formed "safety committees," with this very object in view. Their slogan is "safety first." They coöperate with all the employees in devising measures of safety for the protection of life and limb in all branches of railway operation. Methods of this kind should be extended and encouraged.

Railway Employees of All Grades should be Amenable to State.

Much has been accomplished by Germany and other European countries in checkmating preventable accidents in railroad operation by making railroad employees amenable to the state for negligence in the performance of their duties. Thus far, however, when effective disciplinary measures have been suggested as a deterrent to carelessness in operation, the difference in the sociological and political conditions existing here and in European countries has been cited as an insurmountable obstacle to such methods, even though a majority of the European countries are in advance of us on this question, a start has only been made in the direction of eliminating the human equation from railroad operation. The American people, the most efficient on earth, could accomplish much in this same direction if they but tried. A new idea cannot be perfected without some experiment, and until an honest attempt is made to find out how far the methods in vogue in the European countries may be relied upon in this country, it will not be known to what extent sociological and political conditions enter as factors into this problem.

The Railway Employee's Interest in Corrective Measures.

The operation of railway trains is fast developing into an important and superior vocation, and all right-minded employees

are beginning to realize the necessity of the introduction of effective means to protect them personally from the dangers attendant on the negligent acts of incompetent, careless or indifferent employees. It is conducive to their own interests and safety to encourage and advance such projects.

Remedy for Fallibility in Railway Employees.

To accomplish this purpose, it may be necessary for the state to go beyond the corporate entity and its executive officers and hold each individual employee responsible for the proper and safe performance of his individual duty. This may be brought about in many different ways, and it is suggested that it may be effected in the following manner:

Employees engaged in train operation should be required by law to serve an apprenticeship of a sufficient duration to qualify them for the position they seek. Before the applicant is permitted to serve in any capacity in train service, he should be examined by a competent state board of examiners as to his physical and mental qualifications. Such examinations and tests should be graduated so as to meet the requirements of the different grades of the service, and a license should define the kind of service the applicant may perform, the state to reserve the right to revoke the license for good cause, which should be renewed only upon satisfactory showing.

Most of the states have legislation of this character as to physicians, lawyers, dentists, undertakers, electricians, horseshoers, plumbers, stationary enginemen, barbers and others, for no other purpose than to protect society, and it is needless to add that excellent results have been secured. As far as the public is concerned, it is difficult to understand how the ability and requirements of the horseshoers, barbers or plumbers are of greater importance to society than that of railway employees, and if it is possible to reduce indiscretions and incompetency in the classes mentioned by effective legislation, it should not be difficult to extend similar legislation to railway officials, managers and employees, with corresponding benefit.

State Laws Bearing on Omissions of Duty.

Some of the states of the Union now have laws upon their statute books making the omission of duty of railway employees a misdemeanor.

The Minnesota law reads as follows:

"5002. *Other Violations of Duty.* Every engineer, conductor, brakeman, switchtender, train dispatcher or any other

officer, agent or servant of any railway company, who shall be guilty of any willful violation or omission as such officer, agent or servant, by which human life or safety shall be endangered, for which no punishment is specially prescribed, shall be guilty of a misdemeanor." (6638.)

The Minnesota law, however, makes it incumbent upon the county in which the accident occurred to prosecute. Very often the counties do not prosecute, and it may be desirable to have these laws broadened so as to make it obligatory on the state, through the attorney-general, to aid when advisable in the prosecution of any omissions of duty whereby persons are either killed or injured.

Defective Roadway.

The foregoing table also shows that 789 of the preventable accidents were caused by defective track, resulting in 21 deaths and 808 injuries to persons. Insignificant, you might properly say, compared with the casualties resulting from collisions; however, they would not have occurred if the railway companies had provided a safe roadway for the operation of their trains. The fact that 14 per cent. of the casualties from preventable accidents are due to this very cause is of sufficient moment to merit earnest consideration, and it is suggested that careful thought be given the matter of requiring state supervision of all railway roadways, including track, ties, switches, bridges, etc.

Broken Rails.

The table also shows that broken rails were the source of 277 of the non-preventable accidents, causing 22 deaths and 768 injuries to persons, or a total of 790 casualties. Compared with the 4 103 preventable accidents which caused 295 deaths and 5 836 injuries to persons, or a total of 6 131 casualties, it demonstrates beyond question that rail failures are not the main agent of railway disasters, as the public has been led to believe.

Efforts toward Attainment of Ideal Rail.

There is probably no topic associated with railroads that has been or is at the present time being subjected to such thorough study, experiment and research as is that of railroad rails. Several eminent bodies, composed of the ablest engineers and metallurgists in this country, have been for some time past and are still conducting experiments and tests for the purpose of

getting the ideal rail, and their efforts have been marked by considerable progress.

Investigations of Rail Failures.

Many investigations have been made of rail failures. It is not claimed that rails break from their own inherent shortcomings, and it does not seem that rails which have safely stood shipment from the mills, handling and placing into track, should fail from their own innate weakness.

These examinations indicate that breakages occur in rails constituted of good as well as poor quality metal. The failures are largely caused by unusual strains which are induced by severe and abnormal service conditions to which rails are subjected, in which may be included shocks from broken or flat wheels, defective counterbalances, wheels out of round, defective track, improper fastening of rails upon ties and other like circumstances that would tend to produce such strains. Approximately 55 per cent. of rails broken may be classified as being of good metal; the remaining 45 per cent. consists of comparatively poor quality metal. By term "poor quality" is meant rails proving themselves defective after having been subjected to service; it covers such defects as segregation of constituents, unsoundness, brittleness, faulty rolling, including pipe, old seam, flow of metal, split head, crushed head, split web, broken base and other shortcomings, many of which defects it would be impossible to discover at the mill.

Rail Failures during Cold Weather.

These examinations also show that the largest number of rail failures occur during the winter months, and especially during periods of extremely cold weather. This being the case, it appears railroad travel might perhaps be rendered safer if the speed of heavy passenger trains was restricted within moderate limits during at least the era of extreme temperatures.

American Rails v. European Rails.

While rail breakages are practically unknown on European railways, the foreign rails are not by any means superior to American rails; however, the European roadbed, as a general rule, is far superior to the American roadbed, because it is much better built and drained. The rails are screwed in well-preserved ties, and these are bedded with utmost care to secure that perma-

nent evenness and smoothness of surface that is so essential for adequate and proper support for the rails and loads.

Wheel Loads on Railroad Rails.

In England, the greatest allowable or safe weight per driving wheel to be borne by rail, for the Atlantic (4–4–2) and American (4–4–0) types of locomotives is 22 400 lb.; for the Pacific (4–6–2) and Prairie (2–6–2) types, 19 000 lb.

On the state railways of Germany and Italy, the allowable or safe weight per driving wheel is 18 150 lb. Tests and experiences of these foreign railways were their guides in determining the safe limits of wheel pressures.

In the United States the average wheel load has increased from about 22 000 lb in 1885 to 28 000 lb. in 1907, although many driving wheels carry more than 29 000 lb., and some carry over 30 000 lb. per driving wheel; the loading given, viz., 28 000 lb., represents probably as nearly as may be the average driver loading of American locomotives, as used on main stem railways. During the same period the weight of rail in main track has increased from about 65 to 75 lb. per yd. to 85 and 100 lb. per yd., which heavier weights now generally predominate.

The very marked contrast just cited between the wheel loading on rails in Europe and this country indicates that the effect of the wheel load on rail might be a very profitable topic for further consideration and study. The Interstate Commerce Commission, in its report of the accident on the Lehigh Valley Railroad, near Manchester, N. Y., August 25, 1911, states:

> "These examinations . . . should take up the securing of measurements in the track of the actual fiber stresses which are caused by new types and weights of locomotives, and under the different wheels of these locomotives, in order to obtain information from which to judge of the severity of the strains to which the track is daily subjected; in fact, track conditions as they exist at the present time should be dealt with even to the most minute detail."

Rails must be Properly Supported.

It is well recognized that rails must be properly supported and held in place, i. e., the ties supporting the rails must be of sufficient size and number to safely carry the loading intended; they must be so firmly and substantially bedded as to prevent rails from being submitted to any abnormal strains by deflections induced by passing wheels. That this point is important is

demonstrated from a study of the causes of broken rails, from which it is found a great many breakages have occurred right at or near places where tie renewals had just been made. Old bed is often disturbed more or less in putting in new ties, and not sufficient attention is given in all cases to tamping and bedding new ties, which omission results in an irregularity in the surface of the bed of the rail, so that enough shock is induced by a passing wheel to cause the rail to break.

Rails must Not be Mistreated.

Rails are of a molecular structure and should not be unnecessarily submitted to blows from hammers, track mauls or otherwise. Such practices should especially be avoided in cold weather.

Relief from Broken Rails Promised.

If the effective work now being done by those engaged in the preparation of the ideal rail was augmented by a similar effective educational work treating with the proper care of rails and roadbed among the track forces of the railway companies, the prospects for the elimination of rail failures would indeed be bright, and this end may be accomplished by co-operation with the forces preparing the new standard specifications for rails.

Defects of Equipment.

It is also noted from the table that defects of equipment caused 1 981, or about 63 per cent., of all the non-preventable accidents. They were the source of 38 deaths and 698 injuries to persons; sixteen more deaths occurred from this source than from broken rails. This class of accidents leads by far all the classified causes under the heading "Non-Preventable Accidents," and as it is well known, defective equipment frequently causes broken rails. It appears this feature of our railroad practice also merits serious consideration and study. It is suggested that measures be devised for a more thorough and efficient system of inspection of all equipment. These methods of inspection should be so thorough that it would prevent any but good order cars and locomotives to be placed in trains.

Errors in Railroad Operation.

When effective remedies have been devised and introduced for correcting the several foregoing defects in our railway opera-

tions, viz., collisions, defective track, broken rails and defective equipment, relief will have been obtained from 87.7 per cent. of all railroad accidents, 79.4 per cent. of all deaths and 87.1 per cent. of all injuries to persons resulting from such accidents, and when these ends have been accomplished, it will then be time enough to devise means for the elimination of the remaining 12.3 per cent. of the non-preventable accidents that have not then removed themselves by sympathetic contact with the effective application.

Automatic Block Signals.

Wonderful progress has been made in the development and perfection of the automatic block signal, a device designed to safeguard the movements of trains. The efficiency and reliability of this method of signal protection can probably best be illustrated by reference to the experience gained from such installation by one of our western railways. The company referred to has 454 of these signals in use; they afford protection to 100 miles of single track roadway and to 331 miles of double track roadway. During the year 1911 these signals performed 8 426 990 movements in actual service, out of which number only five false clear indications resulted, and as these false indications were immediately discovered by those in charge of their maintenance, the safe movements of trains were not affected by the failures. One of the failures was caused by defective lubrication of mechanism, the other four were attributed to faulty construction. This is indeed a very remarkable showing and emphasizes in the strongest terms that the possibility of obtaining a false clear signal indication from the present perfected system of signaling is very remote.

That most gratifying results are obtainable from the use of automatic block signals, properly designed and installed, is demonstrable from the experience of all who have used them in train operation, because their use reduces to a certain extent the opportunities for the human agency to err, and as their use also affords adequate protection to train movements, they are of inestimable value in safeguarding these movements.

Many miles of the improved type of automatic block signals have been installed and placed in use by the railways in this country for no other reason than that of availing themselves of the advantages obtainable by the adoption of such means for safeguarding and expediting train movements.

No question now remains but that the public's interest in

the safe operation of trains would be materially furthered and safeguarded if the introduction of the modern efficient automatic block signal systems was required to be extended to include all lines of railways where the prevailing traffic conditions could be materially improved thereby. These extensions should also include all lines that are now handling important traffic with inadequate, obsolete or antiquated signaling devices.

Interlocking Plants.

There are probably no safety devices of greater importance to the public welfare in railroad operation than those protecting and safeguarding train movements over railroad crossings and through junction points at grade and over drawbridges. While it is true that the various states have in the past interested themselves very effectively in seeing to it that ample protection was afforded from errors in train operation at these points, traffic conditions have changed so materially during the past decade that as a general proposition the states' efforts in this direction have not kept pace with the changed operating methods.

In this connection it is extremely desirable and to the mutual benefit of both the public and the railway companies if the rules and regulations affecting the construction and maintenance of these safety devices be uniform in the essential features. These rules and regulations when finally prepared must be flexible enough to be workable and practical under all varying operating conditions, and it appears that this end can best be accomplished by the coöperation of those who are familiar with the operating conditions existing in the various parts of the country.

With this object in view, the railway commissions of the states of Indiana, Illinois, Wisconsin and Minnesota, through their engineers and signal experts, have been at work for the past eighteen months in the preparation of a uniform system of rules and regulations for the construction, operation and maintenance of interlocking plants. The last conference was held in the office of the Minnesota Railroad and Warehouse Commission, in St. Paul, on September 27, 1912. The work is now so far advanced that it will be submitted to the four above-named commissions for approval at an early date.

Laws Affecting Railway Operation.

Laws regulating the number of men constituting train crews, or the experience these men must have before they may enter the train service, have been enacted in 21 states of the Union.

Laws regulating the number of hours of service of the employees engaged in train service have been enacted in 25 states and by the federal government.

Laws regulating the kind of cabooses to be used in train operations have been enacted in 16 of the states.

Laws regulating the kind of headlights to be used on locomotives have been enacted in 14 states.

Locomotive boiler inspection legislation has been enacted in 7 of the states and also by the federal government.

Ostensibly, the purpose of these and other laws regulating train operation is to protect society from the effects attendant upon the occurrence of errors in such operations, and it is probable if all these laws were rigidly enforced, that some measure of additional safety might be realized in this direction. It is a fact, however, that the legislation now existing for the public safety has had very little effect toward removing the most prolific cause of railway fatalities, viz., human fallibility, and unless more effective means are devised whereby this weak point in our railway practice be eliminated, and this is susceptible of accomplishment, our efforts toward approximating perfect safety in railroad operation must impress the public as not having been earnestly or intelligently undertaken.

State Laws.

The lack of uniformity and the varying degrees to which state laws affecting railroad operation are enforced in the different states is very marked. The measure of safety which the public is demanding from errors in railroad operation cannot be expected to be realized without uniform and concerted action on the part of the different states whose duty it is to care for the public interests in this respect. The advisability and fairness of some of the state laws now existing and affecting train operations are also open to question.

Laws Regulating Railroad Operation should be Uniform and Fair.

Because of the confusion which now exists in the different state laws, it appears that both the interests of the public and the railway companies in the matter of safety from errors in railroad operation would be materially advanced if all legislation pertaining to railroad operation was made uniform in so far as the basic principles are concerned, and, necessarily, in the preparation of corrective measures of this character, the local or varying conditions, climatic or otherwise, must be carefully studied and

considered to the end that these rules and regulations when finally prepared, be expedient, fair and practical. Thus it would appear that wonderful results may be accomplished for the welfare of society in this direction by the earnest coöperation of the different states.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1913, for publication in a subsequent number of the JOURNAL.]

PAVING IN SALT LAKE CITY.

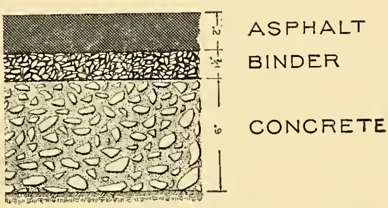
By D. H. Blossom, Member Utah Society of Engineers.

[Read before the Society, October 18, 1912.]

The first paving was laid in Salt Lake City in the year 1891, and consisted of 2 296 sq. yd. From that time up to the present time, approximately 30 miles of asphalt pavement have been laid, $3\frac{1}{4}$ miles of macadam, one third of a mile of concrete and 0.51 of a mile of bitulithic.

The ordinary sheet asphalt will be first discussed, as that is the pavement most commonly used, which the general public is most familiar with and usually thinks of as "pavement" when such a term is mentioned.

Most asphalt pavements in Salt Lake City are laid on a 6-in. concrete base, with $1\frac{1}{2}$ in. of binder and 2 in. of topping. The concrete base is what is known as a $1:3\frac{1}{2}:7$ mix, and is laid directly upon the subgrade.



Refined Asphalt Pavement.

The binder course consists of hard, durable stone varying in size from one inch downward. The stone is heated to from 200 to 325 degrees fahr. Stone and sand are measured separately, and in such proportions that the resulting aggregate will contain by weight, material passing a No. 10 mesh screen between 25 and 35 per cent.; and the bitumen added to this mixture shall amount to from 6 to 9 per cent. of the entire mixture. Such a course, when laid, shall form a comparatively dense and compact mass capable of sustaining the asphalt wearing surface without vibration.

There are two principal reasons for using the binding course; one is to furnish a foundation for the topping to which it will adhere and prevent creeping, and the other is to prevent, to a certain extent, moisture working up from beneath the pavement and coming in contact with the under side of the topping.

The top or wearing surface consists of the following material:

Asphaltic cement	10 to 13.5 per cent.
Portland cement or stone dust passing 200 mesh sieve	10 to 15.0 per cent.
Sand passing No. 80 sieve	18 to 36 per cent.
Sand passing No. 40 sieve	20 to 50 per cent.
Sand passing No. 10 sieve	8 to 20 per cent.
Sand passing No. 4 sieve	4 up to 10 per cent.

The sand and asphaltic cement shall be heated separately to about 300 degrees fahr., the sand in no case exceeding 375 degrees and the asphalt in no case exceeding 325 degrees fahr. The sand is then placed in a suitable mixing apparatus and the requisite amount of asphaltic cement added, after which it is mixed into a thoroughly homogeneous mixture.

The asphaltic wearing surface is hauled to the work in wagons provided with canvas or other suitable cover, and is delivered on the work at from 230 to 280 degrees fahr. It is then spread with rakes to a depth such that, when rolled, the ultimate thickness shall not be less than two inches. The initial compression is effected with a 3-ton roller and the final compression with a 10-ton roller.

Nearly all of the asphalt used in recent years has been furnished by the Barber Asphalt Company, of California, and is a product produced in the process of oil refining. The material is shipped in barrels and is refined and tested to the proper degree of penetration before being shipped. No flux or any other material has to be added to make the asphalt of proper consistency; all that is necessary being to use proper precaution in the melting and heating process to prevent burning.

On all modern plants the vat in which the bitumen is heated is provided with some mechanical means of agitation to prevent uneven temperature in any portion of the vat.

In our opinion, more damage has been caused by the overheating of the material during the process of mixing than by any defect in the material itself. In the plant that has been used for the preparation of most of the material that has been used for work in Salt Lake City, the gravel and sand become overheated, and when the bitumen is added, that portion that comes in contact with each small particle of sand or gravel is scorched or burned, with the result that the life of the asphalt is destroyed, much after the same manner that a piece of rubber is destroyed by overheating.

Another very destructive element is water, and the present method of street flushing is having its detrimental effect. This is especially noticeable wherever cracks appear in the surface or along the street-car tracks where the vibration along the rails causes the cracking of the pavement and the raveling and buckling of the edges.

In a climate similar to Salt Lake, where there is a comparatively wide range of temperature during the season, great care should be taken in the proper tempering of the material in order to get the proper penetration. If mixed too hard it will crack in winter, and if too soft, it will roll and creep in summer, especially so on streets where there is any perceptible grade.

The best authorities agree that the maximum grade upon which it is safe to lay ordinary asphalt paving does not exceed five per cent. both from the standpoint of creeping and slipperiness. This is about the grade of that portion of State Street between First South and South Temple streets.

Until the present season it has for the most part been customary to run the paving material up to and flush with the outer rail of the street car tracks, while a brick or stone toothing has been used on the inside.

On all paved streets the street car company is required by franchise to pave the entire area between tracks and two feet outside of the outer rail at their own expense and with the same character of material as that used by the city.

At present it is for the most part using wooden ties, these ties being laid upon a concrete sub-base with a sand cushion between the tie and the concrete. According to the plans, about $1\frac{1}{2}$ in. sand cushion should be used, whereas in most cases the Utah Light and Railway Company uses from 2 to 3 in., which from a paving maintenance standpoint is too much, as it allows more or less vibration and consequent raveling of the pavement adjacent to the rail.

In order to avoid this difficulty as much as possible, the plan has been adopted, this season, of laying a double row of paving brick outside of the rail as well as the toothing inside of the rail, thereby avoiding as far as possible the vibration which is a direct detriment to the paving laid directly against the rail, as has been heretofore done. Authorities seem to differ as to width of the toothing that should be employed, the object being to have just enough to get away from the immediate vibration of the rail.

Bitulithic Pavement.

Bitulithic pavement, as nearly as we can determine, was first laid by Warren Brothers Company, in 1901. Up to January 1, 1912, there had been laid in one hundred cities of the United States something over 20 000 000 yd. of bitulithic paving, and there was an increase in 1912 of 48 per cent. in yardage laid, over that in 1911, which would indicate that the pavement was fast growing in popularity. Up to October 1, we are informed that 6 337 000 yd. had been contracted for the present season. Scientifically considered, bitulithic pavement properly constructed should be more durable than the ordinary so-called asphalt pavement.

In Salt Lake City we have only one example of this kind of pavement, consisting of approximately 9 000 sq. yd. on North Main Street between North Temple and Second North streets and Center Street from First North Street to Second North Street. The pavement as here constructed is built as follows, having been constructed the present season:

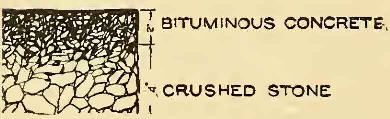
The curbs and gutters are prepared in the same manner as in the case of asphalt pavements. The subgrade for the street paving is excavated to the proper depth and thoroughly rolled with a 12-ton road roller, after which the sub-base material is spread and leveled to the proper depth. The sub-base material in this case consisted of crushed limestone varying in size from $3\frac{1}{2}$ in. down to $1\frac{1}{2}$ in.

Considerable difficulty was experienced in obtaining suitable material for the base of this pavement, crushed bowlders at first being tried without success, the difficulty being that the small bowlders or coarse gravel would pass through the crusher without being crushed, with the result that instead of having an angular product from the crusher, about ninety per cent. of the surfaces were round and smooth, making the rolling and compacting of the base material a practical impossibility, inasmuch as there was no interlocking effect between the different particles of the aggregate, the result being that the mass would constantly creep ahead of the roller. Only a small amount of this material was delivered until the defect was discovered, when the material was changed to crushed lime rock, which was entirely angular as regards its physical appearance.

The one difficulty experienced with this material was that of getting it properly graded and having the finer material and dust screened out. As you all know, there are several grades of limestone in this immediate locality, some being much softer

than others, and in this case the hardest material obtainable was sought. Some criticism was offered to the use of limestone at all, inasmuch as the city's experience with this class of material in macadam pavement on Second Avenue, Sixth East and Tenth East streets had been very unsatisfactory; but this is hardly a fair comparison, as in the case of the bitulithic pavement the base is in no way directly affected by the traffic, nor is it exposed to the atmosphere.

After the material graded as above stated had been properly leveled, the whole mass was again rolled with a 12-ton road roller until it was thoroughly compacted, or until there was no tendency to creep ahead of the roller, the depth of the sub-foundation after rolling being four inches. After the rolling had been completed, the entire surface was sprinkled with a coating of refined asphalt or bituminous cement, the idea being to more firmly cement and bind the base into one compact mass. The base thus prepared is more or less porous and filled with voids, the object being to allow a portion of the topping to penetrate the base, thus making one compact mass of both the base and the topping and thereby preventing any possibility of creeping or rolling.

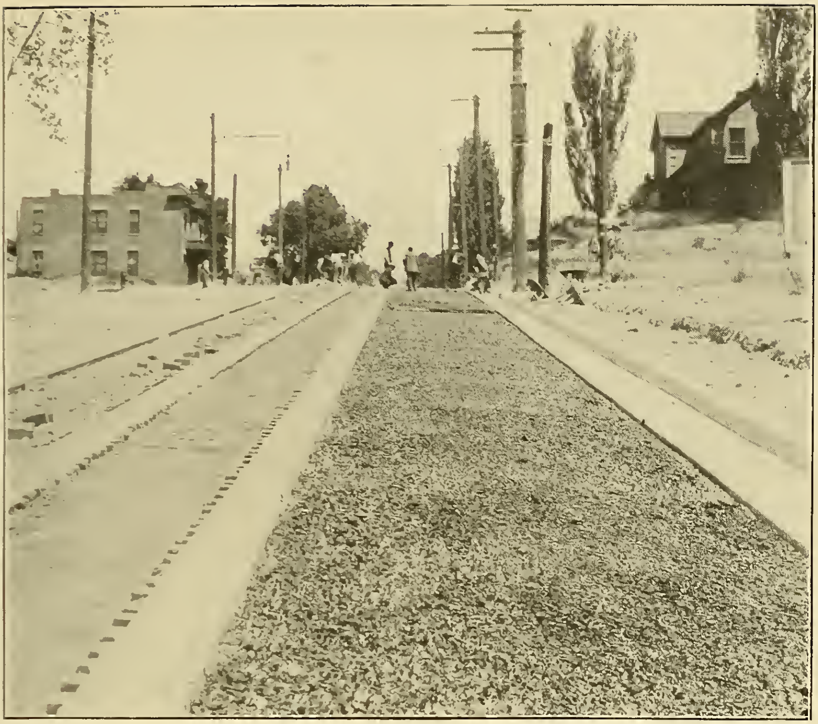


Bitulithic Pavement.

Wearing Surface.

After the sub-foundation has been prepared as just stated, the wearing surface is prepared as follows, crushed bowlders, bowlder chips and clean, sharp sand, and no lime rock or other soft material being used in its preparation, the preparation being entirely mechanical and accurate as regards proportions and mixing of ingredients:

The stone is heated in a mechanical rotary heater to a temperature of about 250 degrees fahr. and elevated to a screen having sections with various sized openings where the material is sized or graded into seven different sizes or grades, varying from one and one-half inch down to a fine dust. Samples of this material are taken every half hour by a chemist who makes a sieve test and determines the exact proportions of each size necessary to produce a mix with the least possible voids; these proportions are furnished to the man in charge of mixer, and the different sizes of material are weighed on a special scale containing seven beams, one for each class of material.



Center Street. Bitulithic — Crushed Rock Foundation.

Bitulithic — Wearing Surface.

North Main Street. Bitulithic—Squeegee Coating.

North Main Street. Bitulithic—Sand Paper Finish.

You will therefore see that, scientifically considered, at least, the mixture is as near perfect as one can make it, and the underlying principle of the bitulithic pavement is its inherent stability and its lack of voids.

After the aggregate material for the topping has been properly weighed, the charge is dumped into a "twin pug" mixer where the proper amount of asphaltic cement is added by weight to thoroughly coat each particle of sand and crushed stone. The bituminous cement is also heated to about 250 degrees fahr. before being added to the aggregate.

The machine in use on this particular job would turn out 5 batches of 1 100 lb. each, every ten minutes, or sufficient to cover 21 sq. yd. of surface. The topping thus prepared is carried to the street in wagons properly covered, the same as the asphalt topping material, and it is spread upon the properly prepared base in a similar manner with a sufficient thickness to finish when properly rolled to a depth of 2 in.

After the final rolling and before the surface has entirely cooled, a "flush coat" of pure asphaltic cement is spread over the surface by a specially constructed spreading device known as the "Squeegee," upon which, and while the flush coat is still hot, a layer of stone chips is sprinkled, these chips first having been heated to approximately 250 degrees fahr. The whole mass is again rolled with the heavy roller until the chips are thoroughly embedded in the topping, giving it a roughish or sand paper finish, which makes this class of paving especially well adapted for medium heavy grades up to, say, 10 and 12 per cent.

The one chief objection to the use of bitulithic pavement seems to be the fact that it is known as a "patented" pavement, and people object to paying a royalty. It is not a monopoly pavement, as some suppose, inasmuch as Warren Brothers enter an agreement to furnish the topping material at so much per square yard on the work, and they will furnish it to all contractors alike. The agreement filed with the city in 1911 called for a price of $1.45 per sq. yd., but this price varies according to locality, cost of freight and raw material of aggregate.

We do not believe that in streets where the subfoundation is soft or inclined to be marshy this class of pavement could be used with good results without a concrete sub-foundation, which would add materially to the cost, and in that case asphalt pavement would be cheaper though perhaps less serviceable in the long run. The bitulithic pavement is especially adapted to

streets where grades are prohibitive for asphalt pavement and which do not warrant the expense of stone block pavement.

Natural Rock Asphalt.

Natural rock asphalt was first laid in Salt Lake City in 1901, when Commercial Street was paved. This pavement consisted of 2 296 sq. yd. with a frontage of 674 lin. ft. Other streets paved with the natural rock asphalt are West Temple Street from South Temple to Fourth South streets, State Street from South Temple to Fourth South Street, Second South Street from West Temple to First West streets, and walks and drives around City and County Building.

There has been so much controversy, the past season, regarding the merits of Utah rock asphalt, that it is with some hesitancy that we attempt to discuss the subject, inasmuch as the records in the city engineer's office, in so far as we have been able to determine, indicate that, with the exception of Second South Street between West Temple and First West streets, a small amount used on the street known as Postoffice Place, and that around the City and County Building, the rock asphalt used was a California product and not a Utah one.

If all of the Utah product would stand up as well under heavy traffic conditions as that around the City and County Building has stood up under light traffic, the Utah product should make the ideal pavement. This pavement was laid in 1904, and, as we have been informed, it is laid directly upon the natural surface, with no sub-base material of any character whatever.

The material used was quarried near Thistle, Utah, and was delivered at the work directly from the cars. It was then heated in a crude vat with steam appliance and spread upon the natural earth, which had been previously rolled with a hand roller. The coarser nodules were raked out and thrown aside, while the balance was again rolled with a light hand roller, this having been the only treatment applied to it.

The pavement has been down for eight years, with no repairs whatever, so far as we have been able to determine. The small holes or pitting effect that is now noticeable is due to the fact that the material as it comes from the mine is not uniformly saturated with bitumen, some being extremely "lean" and some exceedingly rich. It is the "lean" portion of the material that causes the pitting, as the hardened lumps gradually become

detached from the rest of the mass, leaving the holes and depressions now seen in the pavement.

As nearly as we can determine, the mixture as used around the City and County Building contained about 12 per cent. of bitumen and about 65 per cent. petrolene and 35 per cent. of asphaltene, the former of these products giving it its elasticity and the latter its hardness. These were fortunately about the ideal proportions to give the best results, hence the long life of the pavement.

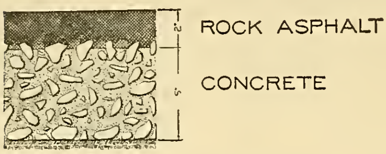
We have also recently taken up some sidewalk laid with the Utah product some fifteen years ago, the material having the appearance of being as "lively" as when it was laid; one sample giving 14 per cent. bitumen, another sample giving 8.6 per cent. bitumen.

The one great advantage as it appears to us that the natural product has over the artificial product is the fact that weather conditions and exposure to the atmosphere do not affect the natural product, while they do affect the artificial product. In other words, there is a certain oxidizing effect that takes place with the artificial product, both from exposure to air and water, that changes its chemical make-up, changing the petrolene to asphaltene and causing the pavement to become brittle and hard, thereby producing cracks and rapid disintegration. On the other hand, the natural product is not affected to any great extent by nature's influence.

The great difficulty that appeals to us in the extensive use of the natural product is the fact that it appears next to impossible to obtain a uniform product in its natural state. There is either an excess of bitumen or a scarcity of it, and even in the same shipment of material there are lumps or nodules of the base material carrying very little bitumen. We believe that by proper grading and mixing of the crude material an ideal mixture can be obtained, but it is questionable whether such a process would not entail such an expense as to make the price of the mixture prohibitive as compared with the refined product.

In drawing our present specifications, an effort has been made to provide for a uniform product, either by mixing different proportions of the crude material to obtain a correct mix or by adding an artificial flux to the lean material or sand to the rich material, as the case may be. The specifications to be used on Fifth East Street also call for a 5-in. concrete base as compared with a 6-in. base ordinarily used, and no binder, as has been the case with the ordinary asphalt pavement. To offset the omis-

sion of the binder, the specification calls for a roughened surface made by sprinkling the surface of the concrete with crushed stone before the initial set takes place, leaving it only partly embedded. This will furnish a better bond for the asphalt wearing surface and prevent creeping or rolling during hot weather.



Rock Asphalt Pavement.

The prices bid for this class of material for the Fifth East paving are the lowest of any ever received for paving of like character in Salt Lake City, viz., $1.74 per sq. yd., and while we are unable to understand how a contractor can make this low figure on a material that is 90 per cent. sand and pay freight charges for sand at the rate of $1.70 per ton, which can be had delivered on the work from the pits adjacent to the city at fifty-five cents per yard, we are of the opinion that if the present specifications are followed, a first-class paving will be had for less money per square yard than any paving of like character heretofore laid in this city.

[Note.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 15, 1913, for publication in a subsequent number of the Journal.]

ANNUAL ADDRESS.

By D. S. Anderson, President of the Louisiana Engineering Society.

[Delivered before the Society at the Annual Banquet, January 11, 1913.]

It has grown to be the custom during the last few years for the address of the retiring President to be delivered during the course of the annual banquet, rather than at the meeting proper. This custom originated, I believe, at one of the annual meetings in which the then incumbent of the secretaryship, with true Teutonic zeal, had prepared such a lengthy and elaborate report of his own as to induce in the members present a condition of super-dryness which it seemed possible to alleviate in no other way than by interposing the refreshing and revivifying influences of the banquet-hall between the Secretary's report and the President's address. So that this is really the report of the *late* President, though I ventuıe to hope that you will not attach to the report itself the usual significance which is attached to the word "late" when applied to a person. That this somewhat incidental change of program was a wise one, however, seems to have been the opinion of the Society for it has been followed at all subsequent annual meetings. It has, indeed, the additional advantage of inducing the deliverer of this constitutionally mandatory address to brevity, and brevity should be the soul not alone of wit but of the words of wisdom as well, which may fall from the lips of the retiring President. In the endeavor, therefore, to conform myself to the mandate of custom and precedent, I shall be brief, even though I may lay claim to neither wit nor wisdom.

With something of that narrow-mindedness, if you please, which makes a man regard every institution, whatever be its character, from the standpoint of his own profession, I have grown accustomed to think of our Society as an educational institution, — a college, in fact, — for you have only to look into your dictionaries to find this definition: "College. — A body or society of persons engaged in common pursuits, or having common duties, interests and privileges." This definition fits almost exactly one of the chief aims and purposes of this body, and in my remarks this evening I wish to try and emphasize particularly this feature of the Louisiana Engineering Society.

That the process of securing an education is a never ending one is peculiarly true of the profession of engineering. And whatever may be the engineer's position in his profession, whether it be that of the young man just starting out as the humble assistant, or whether it be that of the great engineer who sits at his desk and handles with judgment and dispatch the multifarious details of some immense industrial enterprise, there will pass never a day but that the one or the other learns some additional lesson to add to the sum total of his knowledge and experience.

This continuing process of the acquisition of knowledge, however, must have a firm foundation upon which to build, and the preparation of this foundation is the peculiar function of the type of *college* exemplified by our engineering schools, in contradistinction to the type exemplified by the Society in which we are all colleagues. The one is the school in which we are thrown upon our own responsibilities, and in which we may acquire considerable stores of knowledge and experience, if we care to take the trouble; the other is the school in which we are guided by men of experience and authority, and trained, more or less forcibly, in the best methods of securing knowledge. During our school days we are continually in the position of receiving instruction and training from others, while here in the Society we may occupy, if we please to do so, alternately the position of the instructor or the instructed. Each of us should look upon it as a privilege to receive instruction from our colleagues, and each of us should make it our duty to occupy as often as possible the position of instructor.

That the *privilege* is not appreciated to the extent it should be is often evidenced by the vacant chairs in our assembly room, and that the conscience of the individual member concerning his *duty* is not so active as it might be is frequently the cause of regret and worry to the chairman of the committee and the other officers of the Society who are responsible for the programs of the monthly meetings. It is not meant to be implied in this that our monthly meetings are not profitable and of great value to the men who attend them, but rather to call attention to the point that there are many members of the Society who both fail to avail themselves of the above-mentioned privilege, or who neglect their duty in failing to contribute their fair share towards the increase of knowledge and the advancement of the profession to be gotten from their own activities. It may often happen in the course of a man's routine work that he devises a new method

of carrying out certain details, or discovers certain new facts which he uses over and over again until they become to him so obvious and so much a matter of course that he forgets that these selfsame ideas might be of great interest to his colleagues if communicated to the Society in the form of a paper. There is also an incidental advantage here to the man himself which must not be overlooked, and that is that in the course of the discussion on his paper he himself may learn a great deal and secure new and helpful ideas from his colleagues. It is not the intention here to insist that an engineer should give away any of the accumulated knowledge which goes to make up his particular stock in trade and gives him his power and authority in his own special line of work, but there is much that comes within the range of his experience which does not fall within this category, and which at the same time would be of interest and instructive to his colleagues.

There was a good illustration of this in our program of technical exercises during the past year. The chief engineer of an oil mill across the river, a member of this Society, in the course of his efforts to increase the efficiency and economy of his plant, made some investigations upon the use of sawmill refuse as fuel in a producer-gas plant. He worked out a scheme by which he was enabled to use a cheap grade of refuse in a simple and efficient way, thereby greatly improving the economy of his plant. He was requested to prepare a paper upon the subject for the Society, which he did, presenting the whole matter in a brief but comprehensive form, with facts and figures to prove his claims for economy and ease of operation. The paper was published in our JOURNAL and attracted some considerable attention from outside sources. This was helpful and instructive, therefore, not only to us as individuals, but to the advancement and progress of the Society as well, in that it helped to bring our activities to the notice of the outside world.

During the early part of this administration an attempt was made to secure suggestions from the members as to good subjects for general discussion, and to secure promises from members to prepare papers for subsequent meetings. It met with rather scant success, as only a very small percentage of the members replied to the circular letter. I believe, however, that the plan might be tried again with more success, and I venture to recommend it to the new administration.

There is also a decided need for improvement in the matter of regular attendance upon meetings. With the exception of

the two special public meetings held at Tulane University, the average attendance is about thirty-five. A further examination of this attendance would show that a considerable percentage of it is made up of our student members. It is a fine thing for these young men to be there, but it would be finer if we could have at the same time a larger percentage of our more experienced and more prominent members. It would be a safe estimate to say that only about ten per cent. of the membership takes an active part in the affairs of the Society, and, moreover, it is usually the same ten per cent., meeting after meeting. In looking over the reports of our past Presidents I find that several of them have commented upon this matter and have offered suggestions more or less indefinite as to social or other entertaining features which might add to the attractiveness of the meetings. Personally I am a great believer in the value of the social features of an organization such as this, but in the case of the regular monthly meetings it would seem as if our "usual collation" is sufficient to promote the proper degree of sociability and good cheer. We should not lose sight of the point that the main purpose of the monthly meeting is the presentation and discussion of a paper upon some technical subject. It has occurred to me, however, that we might supplement our two great social events, the banquet and the annual outing, by a simple, informal affair of the nature of a smoker, to be given, say, early in the autumn, when we again take up our work after the summer recess. This might have the effect of getting a larger number of men together and having the season's work start off with more of a swing.

I fear that much of what I have said is preaching, but that is a prerogative of the retiring President, and while it has been in a sense critical, it has not been said in a spirit of captiousness, but rather from the strong conviction that for the continuing success of a society such as this it is necessary that each of us should keep in mind the language of the definition above quoted, — that we are a body of colleagues having common duties, interests and privileges. Above all, let us not lose sight of our common duties, and let us not fail to manifest a proper degree of appreciation of our privileges.

It is my belief, and I trust that you will agree with me, that the Society has prospered during the past year. This, in spite of the fact that our membership shows a net decrease of three names, the total number on our rolls being 179. There are two reasons for this. First: A considerable factor in our

yearly increase of membership is the number of student members taken in from the senior engineering class of Tulane University, and this year this class is one of the smallest on record. Second: For the last few years we have been holding on to a number of men who, under a strict interpretation of the rules, were really delinquent, in the hope that we might be able to retain them as permanent members. We have finally been forced, however, to drop a considerable number of them.

The question of the increase of membership is again a feature in which each of us may help along the progress of the Society by constituting himself an individual committee on membership. There are in the city now numbers of men who should join with us, and with the increasing industrial development in this city and state there will be more and more engineers coming here whom we should endeavor to bring into the Society. My experience with another organization in this matter leads me to believe that the most effective method of securing new members is through individual personal influence. A man who under ordinary circumstances will pay no attention to a circular letter or written appeal will often yield to the persuasive arguments of a personal friend. If a campaign along these lines were carried out during the next year, it would be of great assistance to have our membership list revised up to date and published in convenient booklet form.

The technical exercises have been uniformly good, and upon the one or two occasions when papers promised have failed to materialize, we have still been able to present good programs, due to the fact that we have among our number several gentlemen of such wide and varied experience that they are always prepared upon short notice to give us a talk, not perfunctory, but full of interest and instruction for us all. In addition to the regular monthly meetings, we held two special public meetings at which were presented a number of papers and addresses, with complete and full discussion, upon the very interesting and important question of the control and proper utilization of our great system of waterways. The papers and discussion were all published in the official JOURNAL, forming a most interesting contribution to the literature of the engineering problems of the Mississippi and its tributaries.

During the past year we have tacitly given up the former plan of postponing the discussion upon a paper to the next meeting in favor of the procedure of calling for the discussion immediately after the presentation of the paper. It is believed

that experience has proven this to be a good change, and it may still further be improved upon if the writer of the paper would furnish certain of the members with a brief abstract before the meeting.

We have given good support to the official JOURNAL in that we have furnished for publication no less than eleven papers out of a total of seventeen presented before the Society.

Thanks to the committee in charge, the annual outing was a very successful one, the principal feature of the occasion being the visit of inspection to the plant of the Standard Oil Company, at Baton Rouge. A survey of the field as to objective points for our future outings would seem to indicate that we have about exhausted the possibilities within a reasonable distance of New Orleans. The state of our finances scarcely permits of our taking the very extensive trips, such as are gotten up by the great National Societies, to the Panama Canal, for instance. It might be well, then, to consider a suggestion made by one of our members that we charter a big comfortable boat like the *Sidney*, take along our wives, our sisters or our sweethearts, and go off for a good old-fashioned picnic, putting aside for this occasion at least the educational value of the outing, and devoting ourselves strictly to the business of having a good time.

It is with sorrow that we have to record the loss by death during the past year of one of our most distinguished and valuable members, Major B. M. Harrod. He was one of the charter members of the Society and always took an active interest in its affairs, being a contributor to its technical exercises and to the pages of the official JOURNAL.

Again reverting to the value of the educational character of this organization, I feel that I must not close this report without a reference to the close connection which should exist between this Society and the other two institutions in this state which are contributing their share toward the advancement of the great profession of engineering, by furnishing to the best of their resources the fundamentals of the training so essential in these modern days to the success of the young engineer. I refer, of course, to the College of Technology of Tulane University of Louisiana, and to the Agricultural and Mechanical College of the Louisiana State University. That this connection is a vital one is evidenced by the figures in the case of Tulane University, those for Louisiana State not being immediately available, for, out of a total of 179 members, 67 of them, or about 38 per

cent., are connected with Tulane either as alumni, students or professors.

And furthermore, these institutions are constantly turning out new recruits who come to fill up our ranks as we are called upon at the end to hand in our last estimates and file our final reports. They must travel the same rough road of experience over which we have passed, and it is our privilege to extend to them a helping hand. And this helping hand should be extended not alone to the individual, but to the institution as well. All educational institutions are poor, even the richest of them, and our own institutions are no exception, but we look forward hopefully to the time when the state of Louisiana, like her great sister states of the Middle West, will realize to the fullest extent the value of these two schools in the sum total of her assets, and will endow them both with all the resources at her command. And it is not money alone that is needed, but even more that cordial sympathy and support which brings encouragement and uplift. As individuals and as an organization we should feel it a privilege and a duty to help along this great cause, particularly in that feature of it which bears such a close relation to the advancement of our own profession.

And now in conclusion I wish to express my appreciation for the honor of having been your President for the past year, and to thank you for the cordial and generous support you have given me throughout my administration. Our thanks are due to Messrs. Olsen, Datz and Eastwood for the arrangement of this splendid banquet; to our genial Secretary, Mr. Robert, for the novel idea of the souvenirs, and to the agents and representatives of the different companies who have so generously contributed the materials to carry out the idea.

It shall be my pleasure in the future to contribute what I can to the welfare of the Society, and I feel that under the able guidance of my successor, Mr. Shaw, and his associated officers, we may look forward to a year of prosperity and great progress for the Society.

DISCUSSION OF PAPER, "THE REINFORCED CONCRETE COLUMN."

(VOLUME XLIX, PAGE 187, DECEMBER, 1912.)

MR. EDWARD GODFREY.* — With the exception of Mr. Gayler's first few paragraphs, this paper is a sane and logical presentation of the case of the reinforced concrete column. It seems to emanate from an investigator and not from an interested enthusiast.

The part of the first few paragraphs to which the writer would take exception is that which holds out formula (1) as logical. If a column were merely a plaything for the investigator in his laboratory, this formula might have some value as guiding him in arriving at its compressive strength, provided he could do what builders of structures find it impossible to do, namely, produce exactly the same conditions in the manufacture of every test column.

But the real fault with this formula for use in designing structures lies in the fact that the conditions in a monolithic structure bear scarcely any relation to the condition of an isolated column in a testing machine, particularly a so-called reinforced concrete column — one with rods and no hoops embedded in it.

One of the most important characteristics of a column in a structure, where the columns have any part in resisting swaying forces, or in a monolithic structure, is or should be toughness. This quality is of the utmost importance in a monolithic structure to insure safety, and it is the quality that is eminently lacking in a rodded column. Furthermore, it is the quality that the testing machine fails utterly to record. This is why so many great failures have taken place of buildings having rodded columns. Results of tests in laboratories have not been properly interpreted.

If it were possible to cast a column and a girder in cast iron or cast steel, at one pouring, the engineering profession would very quickly learn, if such construction were attempted, the danger of it. Concrete is much more brittle than cast iron or steel, and shrinkage stresses play relatively a greater part. Steel reinforcement for tension overcomes this defect, but steel reinforcement for compression simply makes matters worse.

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*M. Am. Soc. C. E.

The spalling off of large chunks of a rodded column is in no wise inhibited by the presence of upright rods.

It is because the rodded column is an error that any formula that purports to show its strength in a structure cannot be logical.

A feature of the hooped column that has not received the attention it merits is one that is of the utmost importance. It explains the great strength of *some* hooped columns. This feature has, the writer believes, been totally ignored by writers, if his own writings on this subject be excepted.

It is a well-attested fact that a thin disk of mortar or concrete, or even of metal, has a strength in compression very much greater than a short cylinder or a cube. In the case of lime mortar, the difference is enormous. This explains why a hooped column is strong, provided the hoops are strong enough to take the tension and provided they are closely spaced. The concrete is in short disks between the hoops, and these disks have a great ultimate compressive strength. But when the disks between these hoops have once been given a compressive strength, it is absurd to add to this a value for the hoops themselves, for the column may fail between the hoops, and, no matter how strong the hoops may be, they would not add to the compressive strength of the disks. Here is the absurdity of Considère's formula, and it is the error that writers have made in using that formula. The ultimate strength of the column is dependent upon the closeness of the hoops, but, above a certain limit, is not affected in the least by adding to the strength of the hoops.

The hooped column is eminently safer in a structure because of its toughness, but tests have shown that high compressive values for the concrete are wrong, because the column begins to spall long before its ultimate strength is reached, and its high ultimate strength cannot be made use of.

Editors reprinting articles from this JOURNAL are requested to credit the author, the JOURNAL OF THE ASSOCIATION, and the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES.

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VOL. L. APRIL, 1913. No. 4.

THE UNIT METHOD OF REINFORCED CONCRETE CONSTRUCTION.

BY JOHN E. CONZELMAN, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club on January 15, 1913.]

UNIT construction has arrived. The large number of structures built after this method during the last few years shows that unit construction methods can be successfully used for practically all kinds of reinforced concrete construction. We now know that contracting companies exploiting unit methods have a fair chance of obtaining contracts in open competition. In a great many types of buildings, unit construction is so obviously the logical and elegant way that, to one familiar with these methods, the usual construction seems most crude and cumbersome. The change in the attitude of the architects and engineers toward this type of construction is nothing short of marvelous, and it is very gratifying to those of us who, during the last few years, have advocated unit construction in the face of almost universal adverse criticism to be able to say that our labors have not been in vain.

With your permission I shall consider the general subject of unit construction very briefly before confining myself to the subject-matter of this paper. In order to save words, I shall use the term "monolithic concrete" to indicate concrete that has been deposited in its final position into forms, in the usual manner. This word "monolithic," by the way, has been responsible for much misapprehension as to the nature and properties of reinforced concrete structures. No building or large structure is monolithic, using the word in its proper meaning.

We now know, or rather we better realize what we have always known, that the usual reinforced concrete building is not "a monolith carved out of the solid rock," as we used to read in some of the catalogues, but has a great many cracks and joints. The cracks are a necessary result of the method of construction which involves the pouring of a large expanse of concrete at one time; this concrete must shrink as it dries, and cracks inevitably follow. Temperature stresses are also a prolific source of cracks. Joints occur whenever the work is stopped, even though the interruption in the pouring is of very short duration.

Admitting, then, the existence of joints and cracks, does it not appear logical to adopt a method of construction which eliminates the shrinkage proposition, partially eliminates temperature stresses, and, finally, puts all the joints just where the designer intended they should come?

The possibility of properly inspecting the finished product before it is incorporated into the structure is a great advantage peculiar to unit construction. You do not, as a rule (at least if you are at all particular as to quality), buy finished lumber before the bark is taken off of the tree, and yet a great many people are satisfied to purchase reinforced concrete in just that way.

You cannot place too high a value on this one great advantage of unit methods. Just think of the loss of life and property that would have been averted if the art of reinforced concrete construction had *begun* with unit methods instead of ending with them. No accidents from premature removal of forms can occur when unit methods are used.

The subject of unit construction has been discussed to such an extent recently that further exposition of its advantages seems superfluous. However, as the subject is a most important one, I will mention a few of the more obvious points of superiority.

Under unit methods it is entirely possible to follow a well-thought-out program for the work in hand. The forms are bedded on the ground in a suitable casting yard and the work so arranged that a routine operation results; this means that it has finally been possible to enforce factory methods in construction operations; and factory methods, applied to the contracting field, mean order out of chaos.

Forms for similar units are grouped together, thus making inspection and the checking of the reinforcement an easy matter.

The placing of the steel can be done more easily and with

greater accuracy; and the reinforcement is not so likely to be displaced as in a monolithic building, where there is necessarily considerable walking or wheeling over the steel that has been placed.

It is possible to make very thin sections when units such as wall slabs are cast flat; this results in economy of materials.

Unit forms can be kept clean, — shavings, sticks, etc., cannot be washed into them from connecting forms, as is the case in monolithic work.

The question of inspection and testing of the units has been treated fully above; it may, however, be necessary to explain how shrinkage is eliminated. I grant you that each individual unit will have its own internal shrinkage stresses, but these are not cumulative and do not affect the structure as a whole. The shrinkage of the small amount of grout used cannot affect the structure.

It would be possible to give many other advantages of unit construction methods, but I will desist and close this portion of my paper by saying that in my contracting experience unit methods have made possible the adoption of reinforced concrete for buildings that would otherwise have been built of ordinary construction on account of the excessive cost of monolithic construction.

It will not be out of place at this point to review briefly the work that has been done under unit methods.

The first unit constructed buildings of which we have a record were constructed during 1908 by Mr. William H. Mason, superintendent of the Edison Portland Cement Company at New Village, N. J. These were one-story buildings constructed of unit columns, girders and slabs, the walls being built in the usual way. No attempt was made to connect these units by means of projecting bars and grout, but the columns and girders were fastened together by means of steel splice plates and bolts.

At about this same time a warehouse was built in Kansas City from designs prepared by the speaker. In this building rigid joints were obtained by means of projecting bars and a small amount of field concrete; the wall slabs were also cast flat and set into place.

During 1909 a building was constructed at Reading, Pa., for the Textile Machine Works. This building was constructed under the direction of the Concrete Steel Company of New York according to the Visintini method.

During the same year a car barn was built at Harrisburg,

Pa., under the direction of Mr. Mason D. Pratt according to unit methods. This building is of similar construction to the kiln buildings of the Edison Portland Cement Company, except that the wall slabs were also cast unit. No attempt was made to obtain a rigid or unitary structure by means of specially designed joints.

During this year a building was designed and constructed under the direction of Mr. Chas. D. Watson at Syracuse, N. Y. This is a one-story building with bolted connections between members.

Mr. Watson read a paper at the 1910 meeting of the National Association of Cement Users in which he covered the field of unit construction thoroughly. A large portion of this paper is devoted to a description of unit floor joist or unit floor systems, and brings out the fact that at that date the largest application of unit methods was in such construction. I mention this fact because it shows that only two years ago unit construction, as we now use that term, was not highly developed, at least in the Eastern states.

Outside of building construction, unit methods have been extensively used by the railroad companies for the construction of bridges. Notable examples of pioneer work of this kind can be found in the track elevation work in Chicago. Several arch bridges of the three-hinge type have been constructed in the extreme West under patents granted to W. M. Thomas; one of these bridges has arches with spans of 103 ft.

The Ransome Engineering Company of New York has also developed a unit method, and has constructed quite a few buildings; this method is a great advance over the constructions described, as it can be applied to buildings of more than one story in height. In this system, however, the floor slab is poured "*in situ*," making the construction only partially unit. As you know, the floor slab concrete is a large percentage of the total, and it seems to me that a large proportion of the savings made possible by unit methods is, therefore, lost.

There have been quite a few buildings constructed by this method, and the following are the more important:

A four-story manufacturing building for the United Shoe Machinery Company at Beverly, Mass. This building is of pleasing architectural design, being, in fact, an addition to existing buildings which had also been built under Mr. Ransome's supervision. It is stated that quite a substantial saving in cost was effected by the adoption of the unit method.

In Boston during the last two years several buildings have been constructed by this method by the local licensees of the Ransome Engineering Company.

The first application of this method was in the construction of an office building for the Foster Armstrong Company, near Rochester, N. Y. This building has brick bearing walls; its dimensions are 50 ft. by 60 ft., two stories and basement.

Even in this well-devised method there is still no attempt made to obtain the rigidity and continuous action that should be the distinguishing feature of reinforced concrete construction whether unit or monolithic.

A successful unit system must, therefore, be one which can be applied to the construction of practically all structures which would ordinarily be built of reinforced concrete. An example will illustrate the point I am trying to make. Suppose it was desired to construct a very tall building on a very narrow lot. In this case the stresses from horizontal wind loads would have to be taken into account. It is evident at once that a unit method of construction could not be used in this instance unless it were one in which the joints were so designed that the necessary stiffness and knee brace action could be developed.

The Unit Construction Company of St. Louis has such a system, and during the last five years has perfected its methods to such a degree that structures which have all the rigidity characteristic of the monolithic type can be erected in which only 3 per cent. of the total concrete is poured "*in situ.*" All the joints in this system are made by means of projecting reinforcement. The bars projecting from abutting units are made to lap a sufficient length to develop the requisite strength when imbedded in the grout which is used to make the connection. As this company is by far the largest factor in the unit construction field (in fact, the only large company exploiting unit methods), a description of the present status of unit construction will necessarily treat largely of its work. This is especially so since the Unit Construction Company has recently acquired the patents and good will of the Ransome Engineering Company.

Unit construction affords a great field for research work, and in order to develop and demonstrate our methods a testing laboratory was equipped with a 50 000 lb. testing machine and other necessary apparatus. This laboratory has proven to be a very valuable adjunct to the engineering department. Among the experiments that have been made are two series which I think of sufficient interest to merit description: The one series

was devised to throw some light on the subject of bracket design; the other, on the action of girders after connections had been grouted.

In regard to tests on brackets: These were made because there is no satisfactory analysis for bracket design, and no experimental data are available. It is hoped that the information derived from these experiments may be of value to the profession.

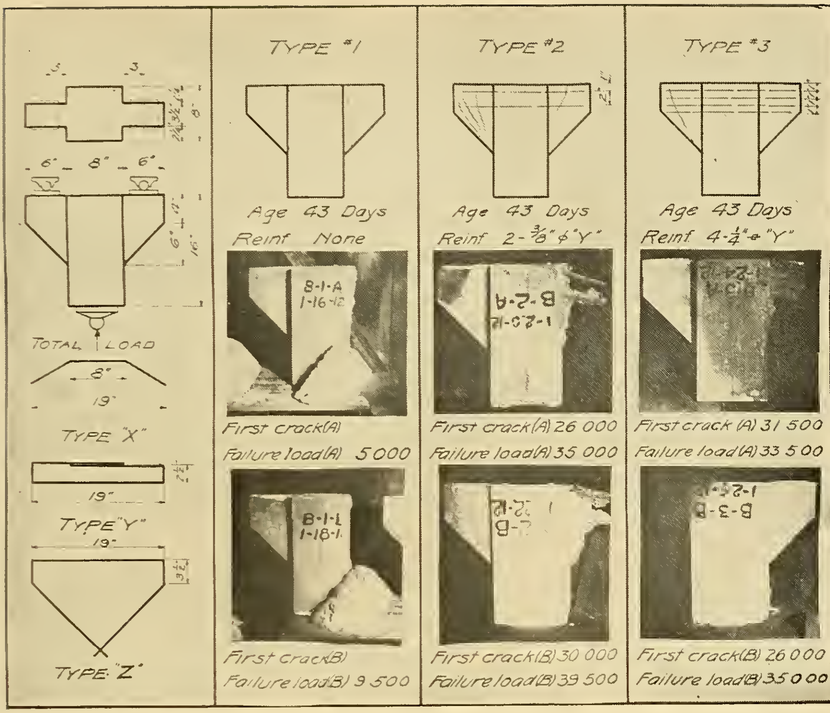
The dimensions of the specimens are clearly shown in Fig. 1. The concrete was a 1 : 2 : 4 mix, the aggregate being Meramec River sand and gravel. The specimens were tested in an inverted position on account of greater ease in handling. The load was applied through a hardened steel ball bearing in a cup-shaped depression in a heavy steel plate. The brackets rested on 1 in. by 4 in. steel plates carried on rollers, as indicated in sketch. Even bearing between plates and concrete was assured by means of plaster of Paris joints. Seven types of brackets were tested, type one being without reinforcement; the others reinforced as shown.

Three types of reinforcement were used, singly and in combination. Type X is a short length of bar bent downwards at each end; type Y consists of a single bar bent in the shape of a rectangle; type Z consists of a single bar bent to follow the shape of the bracket. The type Z reinforcement is, as you know, the type usually employed.

The specimens were tested at the age of six weeks, as nearly as possible, except type 7 specimens, which were tested at the age of sixty-two days. Two specimens of each type were tested, and Fig. 1 and 2 show clearly the condition of the specimens after failure. The load causing the first noticeable crack and the load causing failure are also shown. The position and extent of the cracks are shown in the sketch of each type.

As was to be expected, none of the specimens failed through tension in the steel. The failures were due to shearing or diagonal tensile stresses, and insufficient bond. The action is similar to that which exists at the end of a beam; the condition is aggravated, however, by the difficulty of securing sufficient bond to develop high stresses in the steel.

Although the conclusions that are derived from these tests are not final, yet the fact is brought out that the type of bracket ordinarily used is the least efficient of the forms tested. The failure is fairly sudden and the concrete is almost completely destroyed. The most satisfactory form is type Y or closed



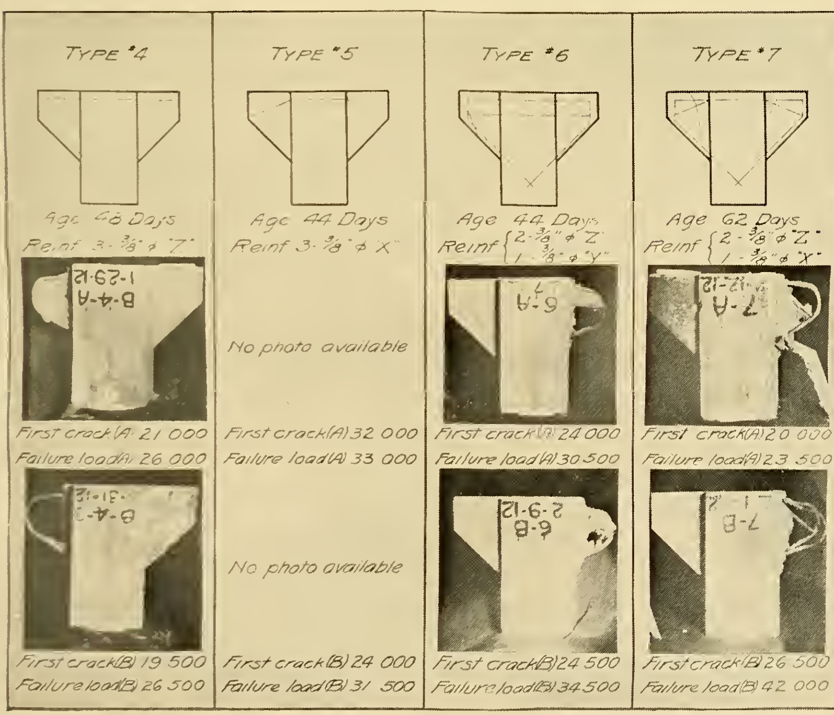


FIG. 1 AND 2. (Courtesy of the *Concrete-Cement Age.*)

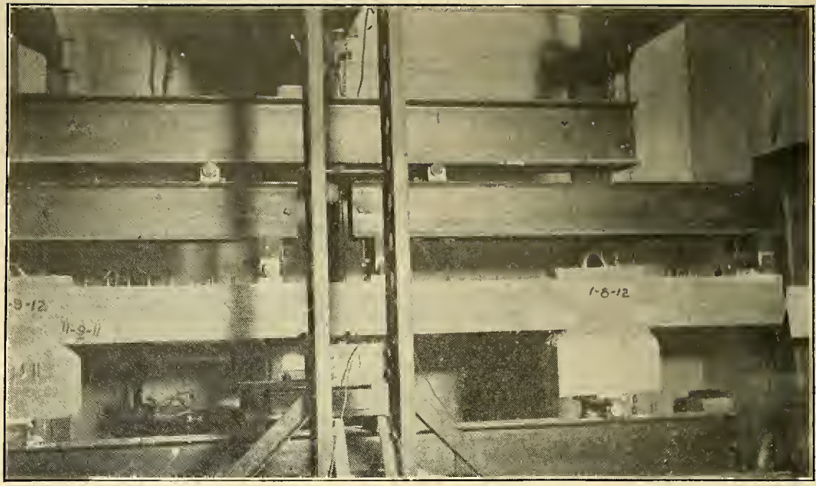


Fig. 3.

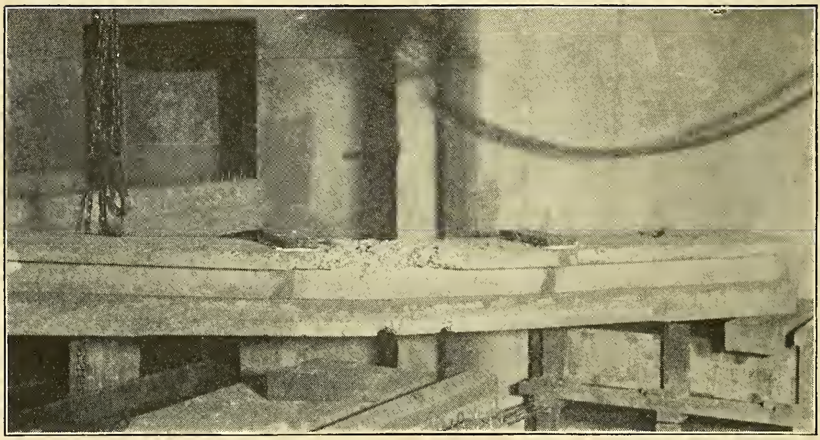


Fig. 4.

Fig. 10.

loop. With a number of loops spaced close together, the failure is slow, and even after the concrete is partially destroyed considerable load-carrying capacity exists. This feature is shown by the photographs of type 3, in Fig. 1.

The average shear per sq. in. on the vertical plane of junction with the column at first load and at failure is given in the following table:

Type.	Shear in Pounds per Square Inch. At First Crack.	At Failure.
1	100	100
2	400	530
3	410	490
4	285	375
5	400	460
6	345	465
7	330	470

A study of these tests leads to the conclusion that the most efficient reinforcement would be the Y type loop bars, some of which would be bent downwards into the bracket. Another series of tests to determine this point is now being made.

An understanding of the details of our system will assist in the understanding of the purpose of the girder tests. I will, therefore, before describing these tests, give a brief outline of our methods. The girders rest on the column brackets. The arrangement of the main reinforcement for the girders follows usual practice, some of the bars being bent up and carried over the support. These bent-up bars project from the unit and lap the bars from the abutting girder. The length of lap is made sufficient to develop the requisite stresses in these bars. You will, therefore, see that after the grout is poured the girders are as truly continuous as in ordinary monolithic construction. The stirrups project above the girder and form loops so as to make a strong connection with the grout which is poured on top of the girder.

The floor slabs rest for their full width on the girder ledge, projecting bars extending into the grout space over the girder. It is evident that, after the grout has hardened, the strength of the girder will be greatly increased on the compression side. In other words, T-beam action results, and the experiments are intended to throw light on this action.

Fig. 3 shows a continuous girder test. The concrete blocks representing the column caps are supported on rollers, the cantilever ends are grouted to the column cap and interior girder in the usual way.

Fig. 4 gives a view of a wing girder, showing failure of compression flange.

The results of the tests on simple and wing girders are given in the table included in Fig. 5. The wing girders failed in tension, the simple girders in compression. The concrete was a 1 : 2 : 4 sand and gravel mix; the reinforcement, high elastic limit corrugated bars. The load was applied at the third points. The extension of the steel was measured on a distance of 8 in. at mid-span; the deformation of the concrete was also measured, steel buttons being set in for this purpose. Readings were made to the nearest one ten thousandth of an inch, and corrections were made for temperature.

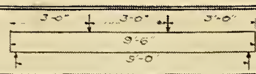
Referring to the wing girders you will see that the deformation of the wings agrees closely with that of the grout over the girder; this means that these wings carried their full share of stress and that full T-beam action was secured. The wing girders carried twice the load borne by the simple beams.

Unit construction presents new problems to the contractor, and the problems cover not only the erection but the casting of the units as well. The difficulties met with in pouring units differ from those encountered in ordinary monolithic work. This results from the fact that in unit work it is necessary to fill a great many individual forms each day, while in monolithic work a comparatively large amount of concrete can be poured in about the same location. In the attempt to meet these new conditions we have tried various types of mixing plants. Two of these plants are of sufficient interest, I believe, to merit description here.

Fig. 6 shows the yard layout for the construction of a plant for the National Lead Company in St. Louis. The sand and gravel were received in hopper bottom cars. A bucket elevator carried the aggregate from the hopper under the track to the bins over the mixer. A mixer mounted under the bins was arranged to discharge into concrete cars, which were operated by a cable on the elevated track shown. These cars were stopped where required, and the concrete dumped into the receiving hopper on the movable distributing spouts. As the spout hoppers were equipped with discharge gates, the flow of concrete could be readily controlled.

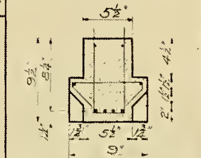
The casting yard was served by a stiff leg derrick mounted on a tower. The derrick traveled the length of the yard and lifted the hardened units from the forms and placed them in the storage yard. A locomotive crane loaded the units on to flat

Stress in Steel lbs per sq in as measured by extensometer.
Load is total applied load



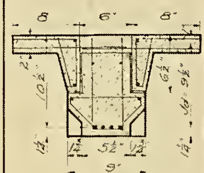
Concrete Deformation given in ten thousandths of one inch as measured by extensometer in length of 8 inches

Girder	Load in Pounds	Maximum Deflection in Inches	Stress in Steel	Concrete Deformation: Left Wing	Concrete Deformation: Middle	Concrete Deformation: Right Wing
G-1-A	8 000	.175	23 400		66	
	16 800	.550	56 100		115	
	17 000					
G-1-B	8 000	.190	23 800		66	
	15 000	.550	58 600		239	
	16 500					
G-1-C	8 000	.170	23 250		57	
G-1-D	8 000	.190	21 750		52	
G-2-A	7 600	.080	10 150	13	14	14
	16 300	.200	26 500	38	38	32
	26 600	.400	48 550	76	70	54
	30 000					
G-2-B	5 000	.075	12 850	19	18	16
	16 000	.185	23 200	41	42	39
	27 900	.380	58 150	89	88	88
G-2-C Made from G-1-C	7 900	.050	10 850	14	15	14
	16 000	.135	25 850	28	31	28
	27 900	.270	50 600	54	53	53
G-2-D Made from G-1-D	8 000	.055	11 750	15	17	14
	16 000	.130	25 850	31	33	30
	28 000	.265	50 050	59	63	60



SIMPLE GIRDER

STEEL $\begin{cases} 2\text{-}\frac{1}{2}'' \square \text{ Str.} \\ 2\text{-}\frac{1}{2}'' \phi \text{ Bent} \end{cases}$



WING GIRDER

STEEL $\begin{cases} 2\text{-}\frac{1}{2}'' \square \text{ Str.} \\ 2\text{-}\frac{1}{2}'' \phi \text{ Bent} \end{cases}$

FIG. 5. (Courtesy of the *Concrete-Cement Age.*)

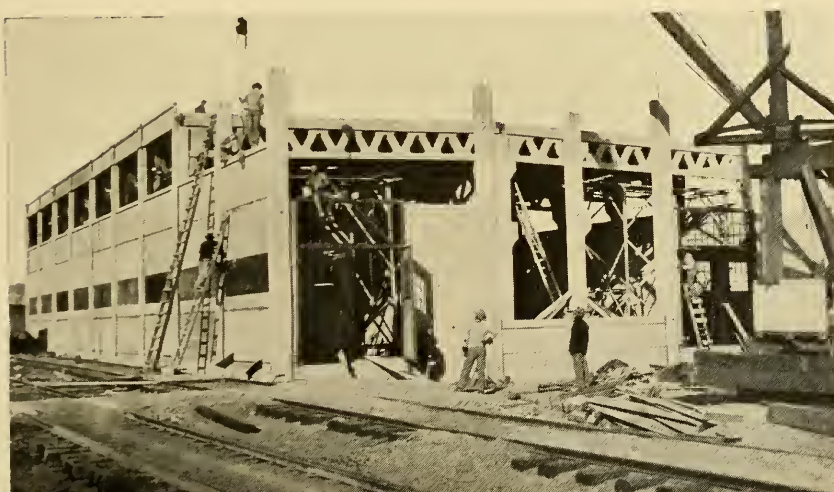


FIG. 13. (Courtesy of the *Concrete-Cement Age.*)

Fig. 6

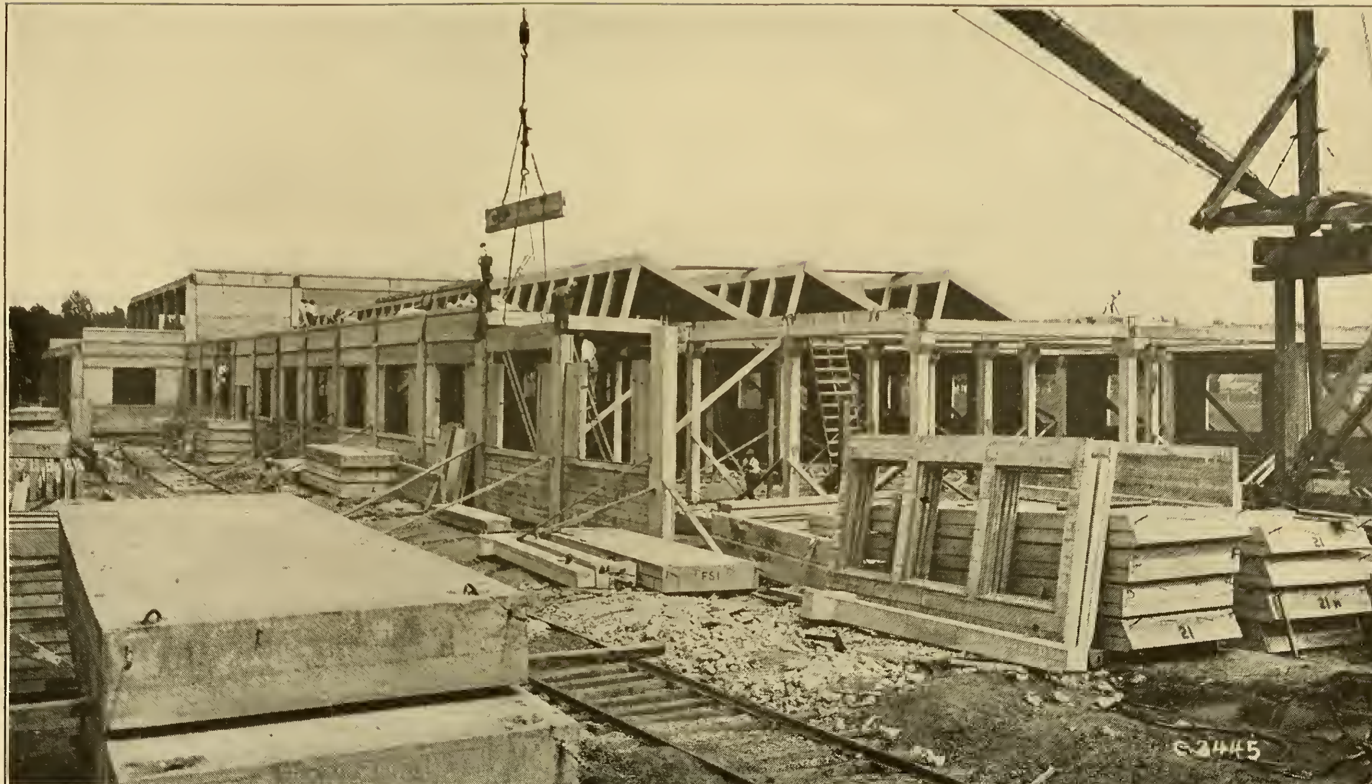


FIG. 11.

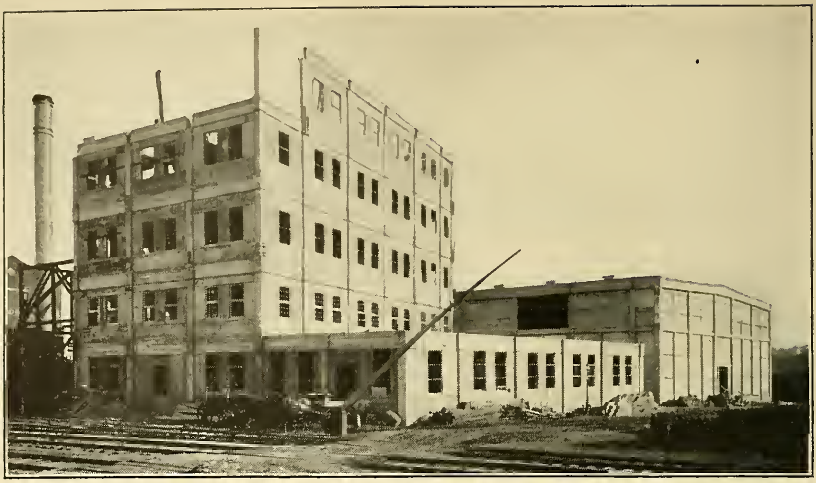


Fig. 7.

Fig. 9. (Courtesy of the *Concrete-Cement Age.*)

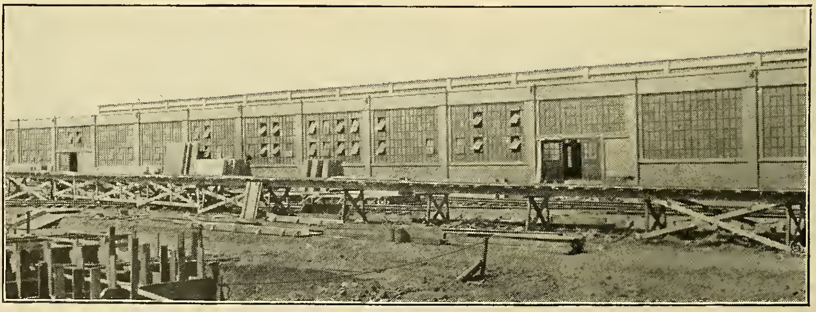


Fig. 12.

cars and pushed them to the building site. The erection was done by a stiff leg derrick mounted on a high traveler.

The buildings are shown in Fig. 6 and 7. As far as my knowledge goes, the five-story building shown in Fig. 7 was the first building over one story in height built entirely of units.

Fig. 9 shows the yard layout for the Memphis Terminal Corporation work at Memphis, Tenn. In this plant the casting yard is circular, the forms being arranged around the concrete distributor. This distributor consists essentially of a structural steel arm, 130 ft. long, revolving through an angle of 270 degrees. This arm is attached to a mast held by stiff legs anchored to heavy concrete footings. The arm carries three spouts as shown on the photograph. With the combination of motions thus obtained, every point of the casting yard can be reached for a radius of 150 ft.

The mixer and concrete hoist are placed behind the mast; a three-way valve, operated by a man on top of the tower, directs the concrete into any one of the spouts.

The casting yard is served by two locomotive cranes; these pick the units from the forms, load them on cars and push them to the buildings.

Fig. 10 shows F. O. B. sheds at Memphis during construction.

The method of constructing the plant of the Sturges & Burn Manufacturing Company at Bellwood (near Chicago) is shown in Fig. 11. By unit methods it is possible to construct sawtooth buildings of reinforced concrete at reasonable cost.

Fig. 12 and 13 show the construction of a cotton mill for the Postex Cotton Mills at Post, Tex. This plant comprises six buildings, only two of which are shown. Fig. 12 is a part view of the mill building. Fig. 13 is a view of the powerhouse during construction, showing 42 ft. reinforced concrete roof trusses.

DISCUSSION.

Mr. Toensfeldt. — How do you get the slab forms out?

Mr. Conzelman. — The forms consist of planking nailed to battens which extend between beams. The planking is supported by joist, which bear under the battens, and are in turn supported by dog bars which rest on the ledge of the beam. By tripping these dog bars the centering may be removed.

Mr. Toensfeldt. — Do you make any attempt to make the floor slabs continuous?

Mr. Conzelman. — We do not because as usually constructed the floor slabs act as restrained beams and are designed

with a moment factor of $\frac{1}{12}$. The floor units consist of a flat plate with beams on the four sides resembling the cover of a box. The inner corners are rounded. The floor beams are figured as of channel section, the tension member is the reinforcement, the compression member the slab. Owing to the construction, the floor slabs are fixed in position with reference to the beams, and it is, therefore, necessary to have some steel near the top of the slab over the beams as in ordinary construction. The beams themselves are fixed in position and cannot twist because they are placed back to back and the space between filled solid with grout.

Mr. Woermann. — What size are the largest slabs you can handle?

Mr. Conzelman. — That is largely a question of the capacity of our derricks. The largest slabs we have placed are about 27 ft. by 5 ft.

Mr. Greensfelder. — How do you support the columns before the grout is poured?

Mr. Conzelman. — The usual method is to support the column by means of a wooden tripod consisting essentially of two planks which are clamped against the column by four bolts. The column is supported until the grout has hardened usually for two or three days.

Mr. Toensfeldt. — In the test specimen, how are the wings fastened to the girder?

Mr. Conzelman. — The wings rest on the girder ledges and have steel bars projecting over the top of the girder. You will note that the top of the wings is two inches above the top of the girder, and that the stirrups in the girder project into the space so formed. The grout space is then poured with a rich mortar in an almost liquid condition.

Mr. Toensfeldt. — Are the ends of the floor unit closed?

Mr. Conzelman. — Yes. As stated before, the slab has beams on the four sides; those on the ends are for the purpose of giving a continuous bearing on the girders.

Mr. Widmer. — How much space do you allow between the sides of the girder and the ends of the floor slabs?

Mr. Conzelman. — Usually from $\frac{3}{8}$ to $\frac{1}{2}$ in.

Mr. Widmer. — What do you use for grouting?

Mr. Conzelman. — That depends on what we are grouting. In the small spaces, as between roof or floor slabs, we use a 1 : 2 mortar; for mass grouting, as in the connection of girders and columns, we use a rich concrete, say 1 : $1\frac{1}{2}$: 3 mix.

MR. TOENSFELDT. — Do you find any difficulty in setting the floor slabs, that is, to get them level and perpendicular to the girder?

MR. CONZELMAN. — No. The floor slabs are usually quite large, and as the clearance allowed is small, it is practically impossible to get them much out of place. Each unit is carefully detailed and will only fit properly if put in the right place.

MR. WIDMER. — I notice that you have a formula there in which you take 0.86 of the depth; does that refer to the percentage of steel?

MR. CONZELMAN. — No, the formula is the ordinary straight line formula with the effective depth taken as 0.86 d.

MR. WIDMER. — Do you use the same formula in the design of wing girders?

MR. CONZELMAN. — Originally it was our practice to figure the girders as rectangular beams, although we knew that after the connections had been grouted up the strength was considerably increased.

MR. WIDMER. — Do I understand that the addition of the wings reduces the stress in the steel about one half for a given load?

MR. CONZELMAN. — Yes, in these particular experiments. The reduction in stress will depend on the dimensions and relative size of the girder and wings, but it so happens that in this case the stress is reduced by one half.

MR. WIDMER. — Is unit construction more economical for work which is spread over a larger area, as at Memphis, than on a compact building?

MR. CONZELMAN. — It is more expensive, mainly on account of the large distances over which the units must be transported and because the erecting derricks must be moved frequently.

MR. ———. — Referring to the concrete distributor used at Memphis, is the work so laid out that pouring can be done through the three spouts at the same time?

MR. CONZELMAN. — Yes, it is possible to use all of the spouts practically at the same time.

MR. HUNTER. — How long do you let the slabs or units lie?

MR. CONZELMAN. — That depends on many things, the temperature, the cement, etc. In summer, five days is usually sufficient.

MR. TOENSFELDT. — Do you pick them up when they are green and transport them to the curing yard?

MR. CONZELMAN. — Usually; at times, however, the units are carried directly to the building from the forms. The forms

are ordinarily made of wood, and sometimes metal lined, and are given sufficient taper or draw so that the units may be easily lifted.

Mr. Hunter. — Do you find the shrinkage of the concrete excessive?

Mr. Conzelman. — No, it is negligible. The units are, within the limits of accuracy of ordinary measuring devices, the same size as the forms.

Mr. Nicholson. — When you have a building of more than one story, how do you get your columns into position?

Mr. Conzelman. — We lift them by means of a derrick and support them temporarily by a setting device, until the grout has hardened.

Mr. Nicholson. — You would have to get a true alignment on the column first?

Mr. Conzelman. — Yes, it is essential, of course, to have the columns in their exact position, and it is easily possible to do this, as the columns can be shifted and plumbed until they are in the proper place.

Mr. ———. — In constructing a building of several stories, do you run each section to the full height as you go along?

Mr. Conzelman. — No. It would be impossible to do this and make the necessary connections. We endeavor to complete the building as the derrick is moved back, but the setting requirements necessitate carrying the construction in steps corresponding to the floor levels.

Mr. Hunter. — In a long building, do you put in expansion joints?

Mr. Conzelman. — Yes, we have a special type of joint in which the girders on one side of a line of columns are connected rigidly to the columns, while those on the other side rest on roller bearings.

Mr. Hunter. — Referring to the power house at Post, do you carry coal bunkers overhead in a case like that?

Mr. Conzelman. — The coal will not be kept in bunkers in this particular plant. The coal will be shoveled from the cars through coal doors in the wall, directly in front of the boilers.

Mr. Hunter. — You could, no doubt, make the trusses strong enough to carry coal.

Mr. Conzelman. — We could make them without trouble, but the difficulty would be in handling them. Our standard equipment is good for fifteen tons with a high boom, and we

naturally limit the weight of the larger units to considerably below this if possible.

Mr. Greensfelder. — I would like to ask Mr. Conzelman if he has any idea how the erection cost per ton compares with the erection cost of steel.

Mr. Conzelman. — I have never thought of it in just that way, but think the cost would be about one tenth that for steel.

Mr. Greensfelder. — Is that due to the difference in weight?

Mr. Conzelman. — I do not quite get your meaning. We make our units as large as we can to meet the conditions and the capacity of our booms. The weight of the average unit is considerably more than the weight of the average steel member of a building. Therefore, the operations required to handle a ton of concrete are fewer than to handle a ton of steel, and the result is lower cost.

Mr. Garrett. — You say about one tenth the cost of steel erection. That is pretty cheap.

Mr. Conzelman. — I can give you an example. The girders for the car house in Philadelphia weigh about twelve tons, and the cost of erection and grouting is about $4 per girder.

Mr. Garrett. — Four dollars for one girder weighing 12 tons is cheap. It would not cost any more to put in place a steel girder, would it?

Mr. Conzelman. — I think it would because of the bolting or riveting required. It costs almost as much to handle a light unit as a heavy one because the sequence of operations is the same; therefore, the heavier the member, the less the cost per ton.

Mr. ———. — Is there any special difference in cost between unit and monolithic construction?

Mr. Conzelman. — Certain types of buildings lend themselves readily to unit methods of construction, but the cost is in a large measure a function of time. The shorter the time allowed, the greater will be the number of forms required, and the expense will be correspondingly increased.

Mr. Greensfelder. — In order to compete, you have to make a different design, do you not? You cannot compete on a specified design.

Mr. Conzelman. — No, it is our practice to submit an alternate design which will, however, closely resemble the original except that the members may have slightly different sections. We of course cannot compete on work unless an alternate will be considered.

MR. GARRETT. — I am not satisfied with that erection cost yet. Do you mean to tell me you can place that stuff for about twenty-five cents a ton?

MR. CONZELMAN. — In some cases, yes. As I stated before, the cost of erecting is to an extent independent of the weight. A girder similar to those under discussion, but weighing only six tons instead of twelve, would cost about the same to erect; the cost per ton, however, would be doubled.

MR. HUNTER. — How much will it cost, Mr. Garrett, to place that quantity of steel?

MR. GARRETT. — It costs about $4 per ton to place steel.

MR. GREENSFELDER. — Do you have to use additional reinforcement due to erection stresses?

MR. CONZELMAN. — In some cases it is necessary.

MR. SCHUYLER. — We have heard about the cost. Can Mr. Conzelman tell us if there is any more profit in this than in regular construction?

MR. CONZELMAN. — That is a question I am unable to answer.

MR. MARTIN. — I might mention the use of unit construction at Evanston, Ill., where a railroad company put in some unit floor slabs that weighed 75 tons each, and had special machinery to handle them. That was in 1906 or 1907.

MR. GREENSFELDER. — Do you claim greater speed for a building erected in this way than the ordinary monolithic construction?

MR. CONZELMAN. — I do not claim that, although we have done some very fast work.

MR. ———. — What type of waterproofing do you use on the external wall slabs?

MR. CONZELMAN. — Ordinarily none, as good rich concrete is practically watertight. Sometimes we finish the surface of the slabs with a trowel, which, of course, gives them an impervious surface.

MR. ———. — You do not use any special preparation then?

MR. CONZELMAN. — No.

MR. ———. — Even on elevators?

MR. CONZELMAN. — In our elevator work we have mixed hydrated lime with the concrete.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]

INITIAL STRESSES IN STRUCTURAL STEEL.

By Joseph R. Worcester, Member Boston Society of Civil Engineers.

[Presented before the Society, February 19, 1913.]

The subject of initial stress in rolled members has received much attention in recent years, but no more than it deserves, for the reason that, under certain circumstances, it may result in very serious consequences.

A few years ago much attention was attached to a series of tests by Prof. Edgar Marburg, of the University of Pennsylvania (Proc. Am. Soc. Test. Mat., Vol. IX), on I-beams of standard section and certain Bethlehem shapes, on account of the extremely low elastic limits reported. The cause of these low results was undoubtedly the initial stress near the junction of web and flange, produced by different rates of cooling of thick and thin metal.

More recently experiments by James E. Howard (Trans. Am. Soc. C. E., Vol. LXXIII) and Professors Talbot and Moore, of the University of Illinois (Bulletin 44), have developed strikingly an early lack of proportionality of stress and strain in built-up columns, which can only be explained by internal initial stresses.

Another striking example of internal stress which has been known to many members of this Society has been in large I-beams which have suddenly, without provocation, split through a large part or the whole length of the web.

For many years it has been recognized that where steel is heated locally for forging there is likely to be produced a region between the heated and unheated portion where the metal is brittle and can be broken by a blow or shock. A striking instance of this came under the speaker's observation recently in the case of some 2-in. diameter steel truss rods which had been upset. One of these, in unloading from a team, had its upset end broken short off with a granular fracture. On testing the other rods, by striking the end with a sledge, it was found that several broke in the same way, while the rest could not be broken.

A chemical analysis of one of the worst ends showed 0.408 per cent. C., 0.045 per cent. S., 0.065 per cent. P., 0.38 per cent. Mn., a result consistent with good metal. Though perhaps not so certainly established as other cases, it is quite probable that this fracture was induced by internal stresses caused by the local heating.

A similar effect in eyebars was noticed, soon after the introduction of steel into their manufacture, and led to the universal adoption of annealing furnaces long enough to anneal the whole bar at one time after forging. This practice has recently been proved by Mr. A. H. Emery to be of no benefit, as far as can be determined by tensile tests, as it decreases both the elastic limit and the ultimate strength, while no decrease in strength appears to follow from the local heat treatment, under direct tension as applied in the testing machine. It does not necessarily follow, however, that the annealing may not be a desirable precaution as a safeguard against shock.

Admitting, then, the prevalence of initial stresses, it is interesting to consider their origin with a view to guarding against them where possible. When their origin is in some form of heat treatment, it is generally possible to overcome them by annealing, though this may not be the only or the best method.

When they are confined to members used in direct tension they may not be of serious import, because, on the application of stress to the member, the effect is to increase the initial tensile stresses already existing, reducing or neutralizing internal compressive stresses. As the applied load increases, a point is soon reached where the fibers carrying most of the tension reach the elastic limit and begin to stretch, after which a redistribution of stress occurs, spreading the stress over all the fibers equally.

A familiar example of this is in the case of a copper wire which may be coiled or crooked with internal stresses. We all know how if such a wire is stretched beyond the elastic limit all crooks immediately disappear. So with a steel member, if in tension it is in stable equilibrium, and a minute stretch can usually occur without harm to the structure.

With compression members, however, the case is radically different. In these, the first applied load, if initial conflicting stresses exist, tends to throw the whole member out of alignment. It is in unstable equilibrium, and the more it bows, the greater the danger.

One of the causes of initial stresses is cold straightening of

metal before assembling. Cold straightening is, in reality, cold bending, and the following investigation is an attempt to determine the limits of internal stress which may be produced by cold bending.

It is well known that material as it comes from the hot bed is almost always more or less out of line, and that in order to straighten it the most effective and simple method, and the one generally used, is to bend the member, in the direction opposite the initial curvature, enough so that when it springs back under its elasticity its alignment will be true. The effect of this bending beyond the straight line and allowing the elasticity to recover it to the correct point is to strain the outer fibers on each side beyond the elastic limit. The elastic recovery reverses the stress in the extreme fibers which have been overstrained, and leaves a condition of stress within the section something as shown by the following diagram:

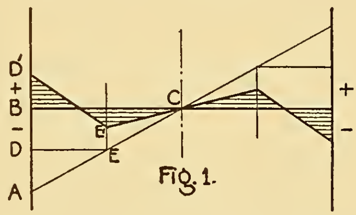


Fig. 1.

This means that starting from one edge of the section we find at first a tensile fiber stress extending in a certain distance in constantly decreasing intensity until it reaches a point of no stress, or a secondary neutral axis, beyond which the stress becomes compressive, increasing to a maximum at a point, the distance of which from the outer fiber is the same as that which limited the field of metal stressed above the elastic limit by the bending. From this point the compressive stress diminishes to the axis of the section, beyond which it becomes tensile again, increasing to a certain point from which it decreases again, again changing to compression at another secondary neutral axis and increasing in compressive stress until the opposite extreme fiber is reached.

In considering Fig. 1, we see at once that with a symmetrical rectangular section we have two fields of tensile stresses and two fields of compressive stresses represented by triangles, and we find that certain assumptions may be made with regard to these fields which serve to fix their amounts.

In the first place, considering the effect of the bending, if the material was not strained beyond the elastic limit, the stresses on each side of the neutral axis would have been represented by a single triangle ABC. If, however, the stress AB is greater than the elastic limit of the metal, this triangle would be truncated by a line DE parallel to the cross section and dis-

tant from it an amount represented by the elastic limit of the material. When the bending stress is relieved, the line DEC assumes a new position $D'E'C$, the distance from D to D' and from E to E' being proportional to the distance from the neutral axis. This proportionality is one of the determining elements. Another is the fact that the total tensile stress multiplied by the distance of its center of gravity from the neutral axis must equal the compressive stress multiplied by its axial distance. This is a necessary condition of equilibrium.

Lest it should be argued that the line DEC does not agree with the stress-strain diagram, it should be borne in mind that in considering the elastic distortion we are dealing with an extremely minute deformation. Between adjacent planes of cross-section it is really infinitesimal, and any finite stretch would be so small as to produce practically no increment in stress. This consideration is valueless on account of its imaginary character. We might, therefore, without invalidating the argument, assume that we are considering the angle between two planes of cross section separated by a finite distance, as, for instance, one inch.

Suppose, for example, a bar 4-in. by 1-in. bent edgewise, to a radius of curvature such that one quarter of its width along the neutral axis is still elastic and the balance, on each side, overstrained.

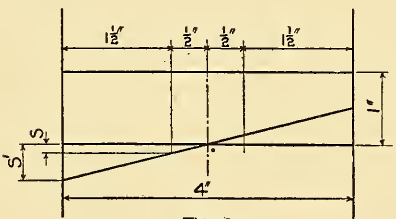


Fig. 2.

Referring to Fig. 2, the stretch S, at the limit of the elastic portion, will be about:

$$\frac{30\,000}{30\,000\,000} = \frac{1}{1\,000} \text{ inch.}$$

The stretch of the extreme fiber S' will be:

$$0.001 \times \frac{1.5}{5} = 0.003.$$

The assumption is that the elongation of $S' - S$ will not cause an appreciable increase in stress after the metal has reached the elastic limit.

$$S' - S = 0.003 - 0.001 = 0.002 = \frac{2}{10} \text{ per cent.}$$

If the gain in strength between the elastic limit and the ultimate is accompanied, as it frequently is, with a stretch of

30 per cent., and we should assume the rate of gain proportional, this stretch of 0.2 per cent. would mean an increase of stress of about

$$\frac{0.2}{30.0} \times 30\,000 = 200 \text{ lb.}$$

But, the characteristic of stress-strain diagrams is that there is a sudden yielding accompanied by a very considerable stretch with no increase in stress, or even a slight falling off. To be sure, in assuming any sharp angle in the diagram, there is a slight error, as the corner should be rounded. It would be more exact to say that the lines assumed are tangent to the curves, but the effect of this rounding may be disregarded without invalidating the theory. Referring to Fig. 3, the above assumptions may be expressed algebraically as follows:

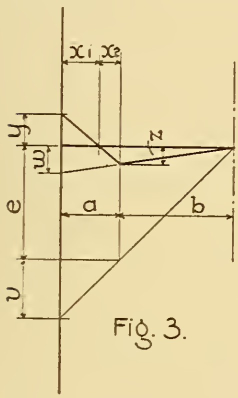


Fig. 3.

$$x_1 + x_2 = a \qquad [1]$$

$$\frac{x_1}{y} = \frac{x_2}{z} \qquad [2]$$

$$y + e = v + e - w \qquad [3]$$

$$\frac{v+e}{e} = \frac{a+b}{b} \qquad [4]$$

$$\frac{w}{z} = \frac{a+b}{b} \qquad [5]$$

$$\frac{y x_1}{2}\left(a + b - \frac{x_1}{3}\right) = (b + x_2)\frac{z}{2}\left(\frac{b + x_2 + b}{2}\right)\frac{2}{3} \qquad [6]$$

Solving these equations, we obtain these values for y & z in terms of a, b & e:—

$$y = \frac{a(a+2b)}{2(a+b)^2}\, e \qquad z = \frac{a^2(2a+3b)}{2(a+b)^3}\, e$$

Letting $a+b=1$, we find that the equation for y assuming a as a variable is a parabola with its vertex at the neutral axis of the section with a value of $\frac{1}{2}e$, the parabola passing through the origin. This equation is $y = \left(a - \frac{a^2}{2}\right)e$, or $2a - a^2 = \frac{2y}{e}$.

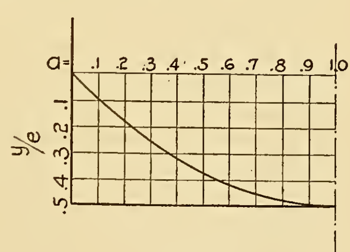


Fig. 4.

Expressing this result in words, it amounts to this: If a rectangular bar is bent so that it has any permanent set, the internal maximum fiber stress may be obtained if we know to how great depth the outside portion of the section has been stressed beyond the elastic limit. The amount of

this internal stress can never exceed one half the elastic limit, and between 0 and $\frac{1}{2}e$ it varies according to the abcissas of a parabola of which the axis is the neutral axis of the section.

We may determine the depth to which fibers are stressed beyond the elastic limit, if we know the radius of curvature and the thickness or depth of the section. We know from mechanics that $\frac{1}{r}=\frac{e}{Ed}$, in which r is radius of curvature, e is elastic limit of the material, E is the modulus of elasticity and d is distance from the neutral axis to the extreme fiber. Using 30 000 for e and 30 000 000 for E, this formula becomes $r=1\,000d$. In other words, the distance from the neutral axis to the fiber which is strained just to the elastic limit will be one thousandth of the radius of curvature; hence, if we know approximately the radius of curvature, we can tell at once what part of the thickness of the section is not overstressed, and, subtracting this from one half the total thickness, can find a. Taking a practical example of this we should obtain the following results.

Assume a bar 3-in. by 1-in. to be somewhat crooked edgeways and to be straightened in a press. Let us assume that in straightening it is curved to a radius of 12 ft., a very moderate assumption.

The width of metal not overstressed would be $\frac{12\times 12}{1\,000}=$ 0.144 in. each side of the neutral axis.

$$a \text{ would therefore} = 1.5-0.144.$$
$$=1.356 \text{ in.}$$

or, on the basis of $a+b=1$.

$$a=\frac{1.356}{1.5}\times 1=0.9.$$

From the diagram, Fig. 4, we find that under these circumstances y, the initial fiber stress, amounts to 0.495 **e**, tension on one edge, and compression on the other, or approximately to 15 000 lb. per sq. in.

This means that in a bar which is quite straight and wholly innocent in appearance there may exist a compressive stress along one edge of 15 000 lb. per sq. in., while along the opposite edge is a tensile fiber stress of an equal amount; in other words, an inherent tendency to bend out of line on the least provocation. This condition cannot be detected by any of the usual methods of inspection, but might be suspected if we knew its history.

It will be noted that the above analysis applies only to a rectangular section. In the case of an irregular section such as

an I-beam, it is evident that if the bending is in the plane of the web, a lesser stress in the extreme fiber will produce equilibrium on account of the decreased area of the section in the parts nearer the neutral axis. On the other hand, however, if the bending is at right angles to the web, the converse is true, and the extreme fiber stress will be greater proportionally, and may easily approach nearer to the elastic limit. The same is true of a bar with a circular cross section.

Let us now consider the practical effect of these internal stresses. Referring again to Fig. 1, we see that if we apply an axial stress to a member which is already subjected to this condition of internal stress the effect will be to produce a condition as shown by Fig. 5.

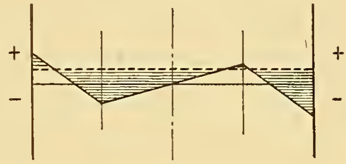


Fig. 5.

In this case we see at once that the areas of stress will be unbalanced so far as the rotating moment is concerned. The effect of this unbalanced condition will be to produce a tendency to spring out of line. If the axial stress is in tension, this tendency is offset by the axial stress itself, and even in case the extreme fiber stress exceeds the elastic limit, a slight yielding of these fibers soon distributes the stress more uniformly and so no serious results can occur. But if the axial stress is compressive, the tendency to spring is very serious and immediately throws the strut out of equilibrium, so that the bad effect of the internal fiber stress is accentuated. If the elastic limit is passed, the buckling may even go on to the point of failure.

It is not the present purpose to enlarge upon applications of the above theoretical considerations, but perhaps enough has been said to show the tremendous importance of eliminating cold straightening so far as possible from the shop treatment of metal which goes into compression members.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]

THE COLLECTION AND DISPOSAL OF MUNICIPAL WASTE.

By G. H. Herrold, Member of the Civil Engineers' Society of St. Paul.

In December, 1912, a committee was appointed by the mayor and common council of St. Paul to investigate the advisability of establishing a municipal plant for the disposal of garbage and refuse and to report plans and estimates of such plans as they might recommend. The commissioner of public works, Mr. Oscar Claussen, is a member of this committee, and it is in connection with the study of this problem for the commissioner that the data presented in this paper have been secured.

In the beginning, when each man dug his own bait and caught his own fish, the nuisance arising from the accumulation of one's household refuse was easily overcome by moving one's habitation to a more esthetic environment. As people have multiplied upon the face of the earth and have gathered together in congested districts, called cities, many problems have arisen which could not be successfully handled by the individual, but have been solved by the community working as a whole. The water carriage of sewage was the solution of one of these problems, and the development of a type of furnace that will successfully destroy mixed garbage and refuse is the solution of another.

In rapidly growing cities the disposal of waste is apt to be handled in a temporary way as opportunity suggests. A study of American cities shows little exception to the generally adopted plan, namely, that of letting out the collection of garbage in certain districts to licensed collectors, who sell to farmers for feeding, and the city's collecting the balance, which, together with street sweepings, rubbish, etc., is disposed of at the city dumps. This is the method now followed in St. Paul. St. Paul is known as the most healthful city in the United States, but its people are not satisfied with this distinction. They wish it to be a clean city. They desire some form of regular municipal housecleaning which will insure scientific supervision of the collection of all waste from the point of its origin to its final disposal. It is necessary in approaching this problem to note that it is an engineering

problem in the administration of the collection system and the design and operation of the disposal plant. It is not a question of public health, excepting as a cleanly environment encourages other cleanly habits. In this connection I quote from an original contribution to *Engineering News* by Dr. H. W. Hill, director of the epidemiological division of the Minnesota State Board of Health:

"Garbage collection and disposal which are essential to comfort and convenience are not in sewered cities affairs which greatly, if at all, affect the incidence of diseases. At most, their relation to the spread of infection is indirect, and that they have any relation is chiefly due to the fly-breeding function of the garbage. Flies breed more readily in manure than garbage, and to remove garbage while leaving manure is simply saving at the spile and wasting at the bung. Let me urge that garbage collection and disposal as details of municipal housekeeping are admirable. . . . But in sewered cities they are only, at most, remotely and indirectly public health measures. The administrative details of garbage collection and disposal do not relate to public health at all."

I also quote from a paper published in *Science* by Prof. Edmund R. Jordan, professor of bacteriology, University of Chicago:

"Sanitarians do not admit that even a grossly improper method of garbage disposal can have much to do with the spread of disease in a sewered city. It is now well known to bacteriologists that disease germs do not 'breed' in garbage heaps, but on the contrary if added from outside they speedily die off. The offensive odors of decomposition may be unpleasant and undesirable, but there is no evidence that they produce disease or dispose to disease. Disease does not originate in garbage piles, however offensive they may be."

The truth is, that garbage disposal in large cities is more a matter of municipal housekeeping than of public health, and proper methods of garbage collection and destruction must be urged rather from economic and esthetic considerations than on hygienic grounds.

Municipal wastes are, as some one has said, "matter out of place"; they can be defined generally as garbage, rubbish, ashes, leather, dead animals, leaves, pieces of wood, straw, small crates, — all of which are combustible, — and bottles, tin cans, pieces of iron, other metal, broken crockery, glass, etc., which are non-combustible. The manner of collecting these wastes depends upon the method of disposal, and the disposal system is one

to be settled from a point of economy for each particular city. Present practice points to the following methods:

1. *Garbage Reduction.* In which the garbage is treated to separate the solids and liquids and recover the greases contained in each. The solid portion after treatment, called tankage, and the grease have a marketable value. For the success of the method, garbage must be separated from all other refuse and must be collected separately. The by-products from the process will pay all expenses of the plant and may return a profit to the municipality.

2. *Disposal by Burning.* In incinerators or destructor plants in which garbage alone or mixed refuse of all classes is destroyed by high temperatures in specially constructed furnaces.

The advantages of a reduction plant are that garbage is made use of for profit. The disadvantages are that it leaves other wastes — rubbish, street sweepings, manure and ashes — to be collected separately and disposed of by other means. It is an expensive plant to build, and, as some odors result from the process, it must be built outside of the city limits and away from human habitation. This makes a long haul for all garbage, and this long haul is a daily expense. The process also requires great skill and a carefully designed plant.

The advantages of the destructor plant or incinerator are that it destroys all germs as well as wastes brought to it. Garbage, ashes and rubbish can be collected by the same wagons and placed in the same receptacles at the house. Recent developments in destructor furnaces have made it possible to erect them at any point, as the best designs do not create any nuisance. It is therefore possible to erect several destructors in a city and thus make a short haul for the collecting wagons. As the cost of collection is three or four times the cost of disposal, under the best conditions this matter of haul is one which must be given great attention. As the city grows, additional plants can be erected. The disadvantages are that the only by-products which can go to help pay the cost of operation are stone dust and clinker, with possibly some steam to spare which could be used for heating or generating electric current.

Some of the notable installations of destructor or incinerating plants are at Milwaukee; Paterson, N. J.; Montgomery, Ala.; Minneapolis; and Seattle, Wash.

A number of cities, especially eastern cities, have privately owned reduction plants to which they deliver their garbage by contract or by city teams. The cities of Columbus and Cleve-

land, Ohio, have municipally-owned reduction plants. The plant at Columbus was built by the city and was the first municipally-built reduction plant in the United States.

The reduction plant at Cleveland was purchased from the contracting company at the expiration of the contract.

The 60-ton destructor plant at Montgomery, Ala., a city of 55 000 people, was built under the following specifications:

1. That the residue from the furnace under ordinary working conditions shall be free from organic matter, thoroughly burned, hard and vitreous.

2. That no nuisance shall be created in the ordinary operation of the plant.

3. That neither obnoxious odors, gas, dust nor smoke shall come from the building or chimney.

4. That the plant while operating as above shall destroy sixty tons of refuse per twenty-four hours, and when operating at this rate shall require three men.

5. That the minimum temperature in the combustion chamber shall never fall below 1 250 degrees fahr., and that the average temperature of the combustion chamber will be about 1 650 degrees fahr.

Seattle has a population of 240 000. They have probably the best planned collection and disposal system that has been designed for any city. They have divided their city into five districts and are building five 60-ton destructor plants, one in each district. Three have been completed. These plants destroy everything in the way of refuse except the street sweepings, which are still used for land filling, but it is the intention to eventually burn these also. There has been considerable said in regard to the possibilities of utilizing the heat from incinerators for making steam to be turned into electric power, which is entirely feasible under certain conditions. In a report made on the Seattle plants by George H. Moore, of the department of public works, Mr. Moore states that their plants use their steam for forcing the draft and aiding in the incineration, and he states that the possibility of steam production for power and electric current is an " alluring theory," but it would necessitate that all ashes and incombustible material be collected and disposed of in some other way. As ashes and non-combustible material amount to from 50 to 75 per cent. of the material taken to the plant, the purpose of the plant would be sacrificed for the sake of making electric current. The clinker output from the furnace is crushed and used for concrete, and the dust which is also a by-product

of an incinerating plant is used by the municipal asphalt plant. An analysis of the materials taken to the Seattle incinerators shows ashes 43½ per cent., manure 4 per cent., garbage 32 per cent., and rubbish 20½ per cent. The total cost per ton of refuse disposed of at the plant is $0.736. After deducting sales of clinker and dust, the net cost is $0.466. The total cost of collection is $1.94 per ton, making a total cost per ton of $2.41; no depreciation or interest is included in these figures.

One of the notable destructor plants is at Milwaukee, Wis. Milwaukee has a population of 375 000. The capacity of the plant is three hundred tons per twenty-four hours. There are four units of seventy-five tons each. The garbage from the entire city and the rubbish from certain portions of the city are destroyed in this plant. The garbage and rubbish are collected separately and mixed at the plant, in the proportion of 60 per cent. garbage to 40 per cent. rubbish, or approximately so. The rubbish furnishes the fuel for the destruction of the whole.

The Milwaukee plant is not an economical one. First, the four units of seventy-five tons each should have been built, not as one plant, but as four separate plants in different districts of the city, and all refuse taken to them. The cost of hauling all garbage to the plant from the entire city has become a burden. Furthermore, as only combustible refuse is fed to the plant, there are great possibilities in utilizing the steam from it for power. There is also no use made of the dust and clinker, which are valuable for asphalt pavements and concrete foundation work. All of these economies are, however, being planned for. The plant has been in operation since May, 1910.

The Milwaukee plant cost $212 000. The average cost of collecting per ton of garbage incinerated is $2.85; per ton of total refuse incinerated, $1.59. The average cost of burning per ton of garbage is $2.92. The average cost of burning per ton of total refuse is $1.62. This makes a total cost of $5.77 per ton of garbage, or $3.21 per ton of total refuse.

The figures include all items such as plant operation and repair, insurance, interest, taxes, depreciation, etc.

The Efficiency Bureau has estimated that there can be saved: by utilizing steam, $36 576 per annum, based on 4 cents per 100 lb. delivered at turbine; using combustion chamber dust for asphalt filler, $1 147; crushing clinker for concrete work, $7 020.

Columbus, Ohio, population 188 000, owns a reduction plant which was put into service in July, 1910. It was the first plant built by an American city. It has a capacity of eighty tons

per twelve hours, or about twice the capacity now required, and it is estimated that it will be good for twenty years. Garbage is collected separately in water-tight steel wagons, $3\frac{1}{2}$ cu. yd. capacity, specially built for the purpose, costing $203 each. It is hauled to a central station, which is a building with a spur track running through it holding two cars. Garbage wagons enter the building on an incline to a floor above the cars and are emptied by means of a hoisting apparatus into the cars. All work is carried on inside the building with closed doors, so as not to cause either odor or unsightliness. Adjoining this loading station are the municipal stables, with capacity for one hundred horses. The city now owns fifty. Offices of the collecting department are upstairs, together with locker bathrooms. The garbage cars are specially constructed with circular bodies on trunnions. The city owns four of these special cars, of 40 tons capacity, or 1 400 cu. ft. Each car cost $1 890. The day's collection of garbage is delivered to the reduction plant at about 8 P.M. in the evening, by railroad switching service. Plant is four miles outside of the city, adjoining municipal sewage purification works. Tracks are high enough to permit handling the garbage by gravity. Car bodies are swung under trunnions and emptied on the receiving floor. Each car is weighed on the track scales to determine the net weight of each load. The garbage is drained. The drainage water is collected and evaporated. The garbage is shoveled into conveyors and is carried to the digester tanks, where it is treated with steam at a pressure of 60 to 70 lb. for six hours.

I do not understand why in practically all reduction works some means have not yet been provided for eliminating the handling of garbage by hand. It seems to me that cars should be dumped on to a movable screen, which after proper drainage would carry the garbage to the digesters.

After this steam treatment the garbage is passed through presses and the liquid passed through grease separating tanks. The grease after passing through a purifying process is put into tanks for shipment and the syrup from the evaporating tanks is emptied into storage tanks. The pressed garbage is known as tankage and is dried and then treated with the concentrated syrup and again dried, making a fertilizer of marketable value.

I understand that since this report was written a naphtha grease extractor has been added, which has made it possible to recover a larger percentage of grease. The state board of health of Ohio, in its final report, claims that this plant is the most per-

fect development of the reduction process which has been reached; no objectionable liquids are produced, as all liquors are evaporated and the condensation water only is discharged. The plant is not inodorous, as odors could be distinguished at a quarter of a mile or more from the plant. There are numerous plants in which the liquid runs away instead of being evaporated, thus creating a nuisance, notably Cleveland, Ohio.

The entire system at Columbus cost approximately $300 000; $200 000 for reduction plant and $100,000 for collection system, including stables, loading station, wagons, tank, cars, etc.

The total tonnage handled in the six months of 1911 was 7 100 tons. The total grease recovered, 206½ tons. Total tankage recovered 1 132 tons, the grease output being 3 per cent. of the green garbage and the tankage approximately 16 per cent. The grease sold at $100 per ton; the tankage from $9 to $10 per ton. The average receipts per month amounted to $4 936. The average operating expense of the plant was $2 500 per month, and the average cost of collection per month was $2 936, so that the total expense, $5 466, was $530 per month more than the revenue. This would make the operations cost the city of Columbus $6 360 per year. However, in this report no interest on investment, sinking fund charge or depreciation had been figured in. If we figure the interest at 5 per cent. and the depreciation on the plant at 5 per cent. and the depreciation of equipment at 10 per cent., we would have to add $35 000. These figures make a total cost of $41 368, or approximately $3 per ton of garbage handled.

In Columbus, as well as in all Ohio cities, there is but one method of disposal of rubbish, ashes and street cleanings, that of dumping on land. The method followed is to place mixed rubbish at bottom and cover with ashes and street sweepings.

The refuse problem presents many phases. There is no objection to feeding garbage to hogs under proper supervision, and this is an economical way of disposing of it.

There is no objection to the land burial method of garbage disposal, where carried on scientifically and where suitable land areas can be found close to the city. In this process the garbage is buried in trenches and covered immediately with about twelve inches of earth. The land returns to a stable condition in from two to three years.

The use of street sweepings and ashes for land filling or road building is legitimate.

The picking over of rubbish to reclaim metal, bottles, etc., that can be utilized may be legitimate.

The picking over of rubbish to reclaim rags, paper, etc., is questionable. It is not alone unsanitary; it is a question of whether we should condemn our fellow human beings to such an unwholesome method of making a living in order to show economies in our refuse disposal system.

All of the above methods are used.

The chief engineer of the State Board of Health of Ohio, the Efficiency Bureau of Milwaukee and the Efficiency Division of the Civil Service Commission of Chicago, have carried on elaborate investigations as to the cost of the various functions of refuse collection and disposal and have published them for the benefit of other cities, making a study of this problem. From these statistics we find the average weight of garbage is 1 150 pounds to 1 475 pounds per cu. yd.; it is unnecessary to add that it weighs the least during the watermelon season; that the average weight of mixed rubbish and ashes per cu. yd. is 800 to 1 100 pounds. In summer the mixture is 35 per cent. ashes and 65 per cent. rubbish, and in winter 75 per cent. ashes and 25 per cent. rubbish.

An analysis of ashes in numerous cities gives $19\frac{1}{2}$ to $24\frac{1}{2}$ per cent. unburned coal.

That a garbage collector can collect from 40 to 90 places in an eight-hour day. That the time spent in getting in and getting out from the houses is about one half of the total time consumed by the collector.

That the average time required to remove garbage from a house is about three minutes. The average rate of travel for a garbage collecting wagon is from $2\frac{3}{4}$ to 3 miles per hour.

That it is cheaper to make the collection with teams; but, after the wagon is loaded, it is cheaper to haul the load to the plant with a motor truck, putting the team on to another loading wagon.

That men should precede the collecting team and bring the can out to the curb, and a man should follow to return the can to the back door, to reduce the idle time of the team.

That a portable paper baling machine hauled by one horse is an aid to the city cleanly and a paying institution.

That in cities the garbage produced per capita is from 175 pounds to 225 pounds.

That the rubbish and ashes per capita are from 325 to 530 pounds.

That the street sweepings amount to $\frac{1}{3}$ cu. yd. per capita approximately.

That the separate system of collection, separating garbage from other refuse, makes a filthy garbage can, which can be a greater nuisance than the garbage.

That the mixed collection of garbage, house sweepings, ashes and rubbish makes a much cleaner material to handle and prevents fly breeding and lessens the dust nuisance from the ashes.

That the mixed collection can be made at less cost than the separate collection.

With these data one can proceed to make a study of any particular city. The first step is to get out a density of population map. This has been done for St. Paul by taking the number of voters registered in the 1912 election and the city directory population for the same time and determining the ratio, which for St. Paul is 5.73. Using this factor and the registration records for each precinct in the city, the approximate population of each precinct has been determined.

The next step will be to work out the cost data for various systems of collection and disposal. Assuming that incinerators will be used, the capacity of each incinerator would be decided upon, say seventy-five tons per day. As we should figure on this plant being capable of handling a certain district for a certain number of years, we figure on running it to a capacity of sixty tons, with the present population. On the basis of the amount of garbage and refuse per capita already given, this size plant would serve 50 000 people.

The next step would be to divide the city into districts, taking into consideration railroad tracks, bridges, grades, etc., with 50 000 population each and with the proposed incinerator plant centrally located in this district.

The question of type and size of wagons must be decided upon. Too large wagons cannot be used where there is much snow. On the other hand, wagons should be as large as possible. In Seattle, wagons of a capacity of 1.6 tons, or about 3 cu. yd., are used, fifteen wagons for each 50 000 of population.

My investigations show an extreme variation of cost of collecting refuse in various cities. It is a problem that should be worked out very carefully. In fact, I believe there is more chance for working out economies in the collection and transportation of waste of a city than in any other field of municipal maintenance.

A reduction plant should also be figured on in order to make a comparison of the cost of two methods. It is probable that in St. Paul such a plant would have to be erected down the river, near the packing houses, and loading stations for garbage established on the levee. The garbage would be taken to the reduction works by means of barges, equipped with tanks which could be hoisted from the barges at the plant and unloaded. The cost of collection would then have to be refigured for handling all garbage to two loading stations, one on each side of the river. It is probable that for a few years we could then continue to use the dumps for ashes, rubbish and street sweepings. Manure is now hauled away by farmers. But it would be necessary to figure on eventually establishing incinerating plants for the destruction of these refuses, as the city becomes more densely populated.

To decide upon the types of furnaces for destructor plants and the system of grease recovery to be adopted, with the necessary machinery, is a problem which will require the inspection of plants actually in operation, showing fully their advantages and disadvantages.

To determine the relative economy of the reduction process or incineration of all refuse the cost must be reduced to annual expenditures, taking into consideration that the reduction process disposes of garbage only. Such costs would include the cost of collection and delivery at plant, operation of plant, interest on the investment, depreciation of equipment and plant, and all repairs, land rental, insurance, etc., and also the credits from stone dust, which can be used in our municipal asphalt plant and take the place of material for which we now pay one dollar per cubic yard; and the clinker, which can be crushed and used as crushed stone is now used; also steam for the generation of electricity or heat; also grease, fertilizer, base, etc., the last two being by-products of a reduction plant.

Proceeding along the above lines, comparison can be made by which we can decide which process would be the most economical. Any estimate of cost of the reduction process must, however, include the cost of disposal of other refuse in a modern way in order to compare it with the cost of the destructor process. St. Paul has an area of 55.50 miles square and over 800 miles of streets. It was evidently laid out for a city of homes, but the large majority of the people prefer to live in apartments, with the result that certain residence districts are thickly populated, while others are very sparsely settled. Any system of

refuse collection makes necessary the traversing of all these streets over the entire area of the city. This will increase the cost of collection per capita as compared with some other cities of the same population but smaller area and with the population more evenly distributed over their areas; furthermore, the apartment house districts are a fruitful field for the licensed garbage collector, as a large amount of garbage can be collected from a small area and in a very fresh condition. It is also garbage very rich in food for animals. A reduction plant would not pay unless 75 tons per day of garbage could be taken to it, and this is very close to St. Paul's present garbage output. Of this, approximately 40 tons are taken by private collectors and the city would have to eliminate these private collectors, if it should adopt the reduction process, in order to make a paying proposition.

The problem is one, however, which can be estimated very closely, and definite figures can be determined indicating the probable per capita cost of whichever process it should be decided to adopt.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]

COLUMBIA RIVER POWER PROJECT NEAR THE DALLES, OREGON.

By L. F. Harza.

[Read before the Oregon Society of Engineers, January 16, 1913.]

It has long been known that the western coast of the United States is provided with immense water-power resources, unequaled by any other section of the United States, except, perhaps, Niagara Falls. That these resources have not led to a great development of manufacturing industries on our West Coast has been due largely to the lack of a western market for manufactured products and high cost of transportation to populous consuming districts in the East.

That these conditions will not long obtain, especially with regard to certain manufacturing industries where the cost of power is relatively great in proportion to the other elements of the cost of production, now seems well assured. The last decade has witnessed the development of a large number of new special industries which have built up around hydro-electric generating centers and owe their existence entirely to their ability to obtain cheap hydro-electric power. Among such industries may be mentioned the manufacture of calcium carbide, cyanamid, carborundum, electrolytic alkalies, graphite, alundum, aluminum and nitrates, ammonia and other nitrogen compounds.

Probably the most phenomenal growth of any industry which the history of this great industrial age has ever recorded is that of the nitrates industry. In 1903 a company in Norway started an experimental plant of 25 h.p. capacity, and this company has now grown until it has in continuous operation 220 000 h.p. used in the manufacture of nitrogen compounds, principally nitrate, for use as fertilizer and also for use in making explosives and some chemical purposes. This phenomenal growth is caused by the rapid increase in demand for fertilizers throughout the older agricultural districts of Europe and America, and by the remarkable cheapness of the hydro-electric power which has thus far been developed in Norway, devoted to this purpose.

For the benefit of any who may not be familiar with the process used in the fixation of atmospheric nitrogen by the

electric furnace, I will say that in an elementary way the process consists of passing air through the electric arc, where the intense heat causes the oxygen and nitrogen to unite to form an oxide of nitrogen which, when passed through water, is converted to nitric acid, thence by application to limestone or sodium or potassium compounds is converted into calcium, sodium or potassium nitrates.

The possible future of this industry can perhaps best be judged by stating that the United States alone now imports from Chile an amount of the natural nitrate deposits of that country to require the use of 900 000 continuous electrical h.p. to manufacture by the electrical process, and the rate of importation is increasing about 10 per cent. per year. Various geologists have reported for the Chilean Government and the various operators in Chilean nitrate upon the probable life of the natural deposits of that country, and the longest life predicted by any of the investigating geologists is fifty years. The nitrate consumption of the United States is only a small portion of that of the entire world. It is also a very significant fact that the Norwegian nitrate is now transported from Norway to San Francisco and Honolulu and sold at a lower price than the natural Chilean nitrate. The market for this product is very rapidly increasing in the immense fruit and other intensive agricultureal areas of the Pacific Coast and the Hawaiian Islands. A representative of the Norwegian Company has estimated that the demand in this territory will increase annually at a rate sufficient to require 80 000 additional h.p. each year. This company is now making an investigation of the water-power projects on this coast with the intention of establishing nitrates works for supplying the West Coast and Hawaiian Island market, and has expressed its interest in the large water-power site on the Columbia River, near The Dalles.

One other electro-chemical industry, in response to correspondence initiated by Mr. Lewis, state engineer of Oregon, has expressed its interest in the establishment of industries in this locality subsequent to the completion of the Panama Canal, and has made tentative offers for the purchase of a large block of excess power.

Tentative offers have thus been made for the purchase of about 300 000 h.p., and under these circumstances it is evident that the large, cheap water powers of this region need no longer await the slow growth of our city population, and the resultant lighting and small power load, to find justification for their

development. Thus the amount of power from the Columbia River project, for which tentative offers have been made by the above-mentioned industries, is about thirteen times as great as the entire present output of the Portland Railway, Light and Power Company, which now supplies the entire lighting and power market of Portland, Oregon City, Salem, and a large part of the tributary territory.

It is the establishment of these large electro-chemical industries which we must encourage if we are ever to use the immense hydro-electric resources which we possess. It is only the development of these industries which has created market for the present large consumption of power in the Niagara Falls district and also in Norway.

The rapid development of these water-power resources can only be accomplished through the furnishing of power, at the smallest practicable price, to new industries. None of these companies would require a contract for longer than forty or fifty years, at which time this territory will undoubtedly be much more densely populated and the value of power much greater because of the increased market thus created for the manufactured products.

The correspondence instituted by Mr. Lewis with the large electro-chemical companies was so encouraging to him as to lead him to engage us as consulting engineers to make a preliminary technical investigation of the engineering feasibility of the Columbia River power project, with estimates of the cost of development and annual cost of power, to determine whether or not power could be furnished at a price which would immediately attract these large industries to this field. We believe that the investigations which have been made are sufficiently complete and accurate to warrant the statement that with a conservative basis of financing through state bonds or government bonds, or even by private capital under proper restrictions as to over-capitalization, power could be developed from this project and sold at a price not higher than $9 per electrical h.p. year, based upon sale at the generating station and at generated voltage. Based upon this showing, Mr. Lewis is seeking legislation at the coming session of the legislature to establish the water-power policy of the state as favorable toward state development, or at least state investigation and promotion and supervision of financing of this and future large projects.

A description of the general engineering features of this project will doubtless prove of interest to this Society, as this

project is undoubtedly one of the largest projects capable of development in the world, and if developed now would be by far the greatest power station under one roof and would occupy the unique position of being upon navigable water for the transportation of materials of construction and the subsequent manufactured products and also with two competing transcontinental trunk line railroads passing on either side of the river at the power site, affording still farther advantages for manufacturing development.

Stream Flow.— The topography of the Columbia River drainage basin varies from the character of the comparatively barren, rugged Rocky Mountains and the densely timbered Cascade Mountains and the mountains of British Columbia, to the almost featureless sage brush plains of the Snake River Valley and of portions of eastern Washington and Oregon. Most of the tributaries rise in high altitude, many of them fed by permanent glaciers, and most of them fed by melting snows in the high altitudes. This feature serves to postpone for several months the season of what would in the eastern part of the United States be the spring freshet, as the snow in the higher altitudes is much slower to respond to the warm weather of spring, thus the maximum flood of the Columbia River occurs in June, which is during the almost rainless season of the year in a considerable portion of the drainage area of the river.

Also many of the tributaries rise and perhaps flow for a large portion of their distance through beds of porous, spongy lava, which exert a wonderful influence upon the regularity of the stream. These streams sometimes almost disappear and reappear again through subterranean channels in the lava, rivaled only by the channels which are often found in limestone countries.

The extremely diversified nature of the climatic conditions encountered on the drainage area of this river, together with the large drainage area (236 000 sq. miles), accounts for the remarkable regularity of the river, free from sudden large floods which occur at least expected times in eastern and middle west streams. The individual characteristics of the numerous rivers combining to form the Columbia, although flashy in themselves, become absorbed or blend into one large stream in which the flashy characteristics of the individual stream become obscured by the averaging effect of their union into one stream. Due to this effect floods of consequence do not occur except at times which can be closely predicted. Records of the flow of the river

are available for thirty-three years, which is also one of the gratifying features of this project, as compared with the average project which one is required to investigate.

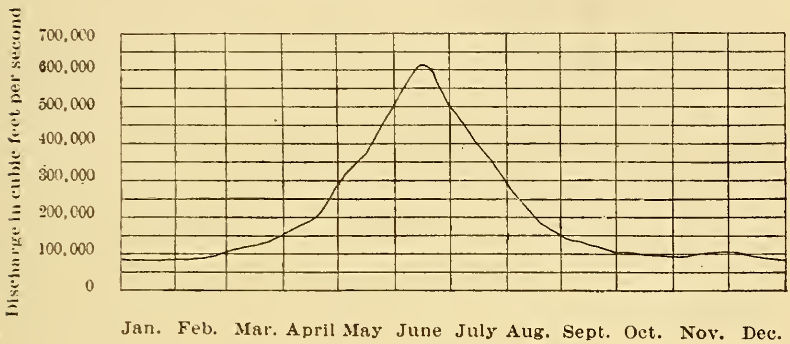


FIG. 1.

Without attempting to go into sufficient detail to show the annual hydrographs, the general characteristics of the stream flow are readily gathered by an inspection of Fig. 1, which shows the average hydrograph of the past ten years. Here will be observed the June flood and the winter minimum flow.

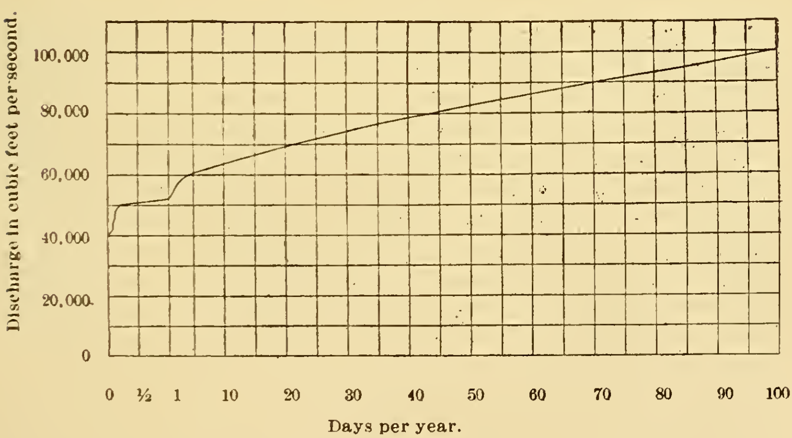


FIG. 2.

The thirty-three years' records indicate that the flow at times falls as low as 50 000 sec. ft. and upon one occasion even lower. In Fig. 2 is shown the duration curve of minimum discharges, showing the average number of days per annum for

the past thirty-three years during which the river has fallen short of discharges specified at the left of the diagram.

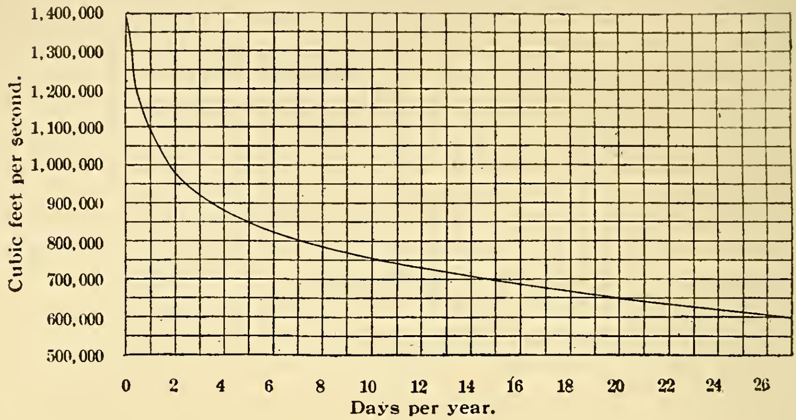


FIG. 3.

In Fig. 3 is shown a similar duration curve of flood discharges, in which is shown the average number of days per annum during which the specified floods have been exceeded. In Fig. 4 is shown a record of maximum floods for the past thirty-three years.

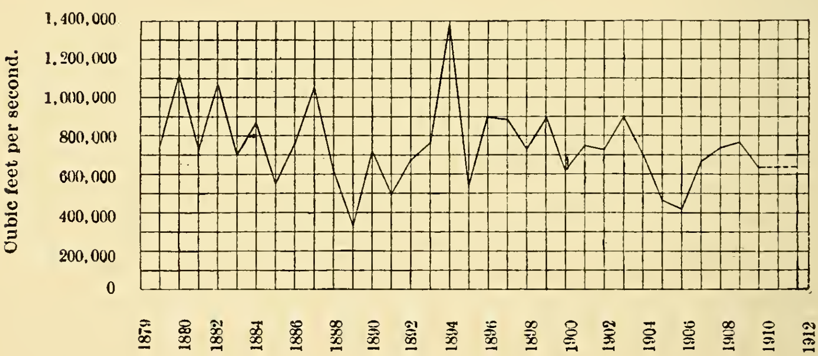


FIG. 4.

It will be observed from Fig. 3 and 4 that the maximum flood is about 1 400 000 sec. ft., which occurred but once, namely, in 1894. The next largest flood is about 1 100 000 sec. ft. and occurred in 1880. The average annual duration of floods of the magnitude of 1 100 000 sec. ft. will be seen to be about one day per annum, and of floods of the magnitude of 1 000 000 sec. ft., about 1.8 days per annum.

Head.—The practicable limit to the developable head most natural to assume is that head which could be secured by permanently maintaining the head water elevation at such elevation as now exists during extreme floods. The transcontinental trunk lines following the river on either bank, namely, the Spokane, Portland & Seattle on the north side and the Oregon, Washington Railroad and Navigation Company on the south side, are constructed with reference to natural flood levels, and so long as past elevations are not exceeded but little damage would be done to these railroads except for a few miles, through which the O. W. R. & N. was flooded during the 1894 flood.

The topography at the power site is such as to practically fix the location of the dam and point of diversion at the head of Five Mile Rapids and to fix the location of the power house at Big Eddy, about 1.5 miles below. Under these conditions a natural fall exists between the dam site and power house site of about 32 ft. during extreme floods such as those of 1894. At a flood of 1 000 000 sec. ft. a net operating head of 42 ft. could be secured without maintaining the head-water elevation above that of the 1894 flood.

During low water a head of 105 ft. is possible by maintaining the head water at the same elevation as during floods. Since the range from 32 ft. to 105 ft. in head is greater than the range through which a hydraulic turbine can operate to advantage, it would be necessary, in order to maintain full power of the stream under this entire variation in head, to install two distinct sets of generating units speeded for different heads so that one set could be used during a variation from say 32 ft. to 65 ft., the other set of units through the remaining range of head. This expense would not be warranted by the short time during which the units would be required to operate under extreme floods or under extreme low water. For the most economic and complete development of a power project it is nearly always necessary to ignore extreme and remote conditions. To successfully operate continuously with only one set of turbines a 32 ft. head would fix the maximum practicable operating head under high water. As a head of 32 ft. would have occurred only during the 1894 flood it would seem best to ignore this head and assume instead a minimum head of about 42 ft., corresponding to that obtainable with a flood of 1 000 000 sec. ft. as the maximum flood, the probability of the recurrence of which is sufficient to warrant the attempt to maintain full power at such times. This assumption will increase the maximum operating

head of the turbines which occurs at minimum flow and therefore increase the low water or limiting power of the stream. It would seem to be better economy to speed the turbines for a minimum operating head of 42 ft., depending upon a partial shut down of service on the very rare occasions, if any, during which the corresponding flood of 1 000 000 sec. ft. would be exceeded, than to attempt to speed the turbines for 32 ft. minimum head, thus reducing correspondingly the low water power of the stream, which occurs much more frequently, the principle being to sacrifice power even to the extent of a partial interruption of service on the rare occasions of extreme floods, in preference to adopting an incomplete development of the low water and therefore limiting the capacity of the station.

With an adopted minimum head of 42 ft. the turbines would operate through a range of heads from there to 75 ft. with entire satisfaction and perhaps even for a head some 10 ft. larger, but it is believed that the erosion of the runner buckets and reduced efficiency under the extremely high head would make the advisability of operating at a head greater than 75 ft. questionable.

Power.—The power which is developable under the assumed low water of 50 000 sec. ft. and corresponding head of 75 ft. gross, or about 73 ft. net, would be about 300 000 continuous electrical h.p. measured at the generator bus bars. Our estimates of cost are based upon the generation of this power by means of vertical single runner turbine units of the same size and type used at Keokuk by the Mississippi River Power Company, and which are the largest size which it would be possible to transport by rail. Runners of this size would generate under 70 ft. head about 32 000 h.p., sufficient to operate a 20 000 kilowatt umbrella type generator. Eleven such units would be required for maximum head conditions, and in order to maintain full capacity of 300 000 electrical h.p. at 42 ft. head twenty such units would be needed. These generators would be of the largest size yet constructed of this slow speed type, although 20 000 steam turbo-generator units have already been built.

Seasonal Power.—Whenever the stream flow exceeds 50 000 sec. ft. excess power would be available, and whenever the stream flow falls between 88 000 and 280 000 sec. ft., an additional output of 236 000 h.p. could be delivered without any additional capital investment. For discharges below 88 000, the stream flow would be insufficient for the entire 236 000 h.p., and for discharges greater than 280 000 sec. ft. the machine

capacity would limit because of reduced head. By the installation of additional machinery this capacity could of course be maintained throughout the high water season. A study of the hydrographs has shown that with the twenty-one 20 000 kilowatt units (twenty for service and one spare unit), speeded normally for 60 ft. operating head and capable of operating at a minimum head of 42 ft. and assumed maximum of 75 ft., there would thus be salable a perennial base load of 300 000 electrical h.p. and an additional 236 000 electrical h.p. available for an average period of about eight months per year.

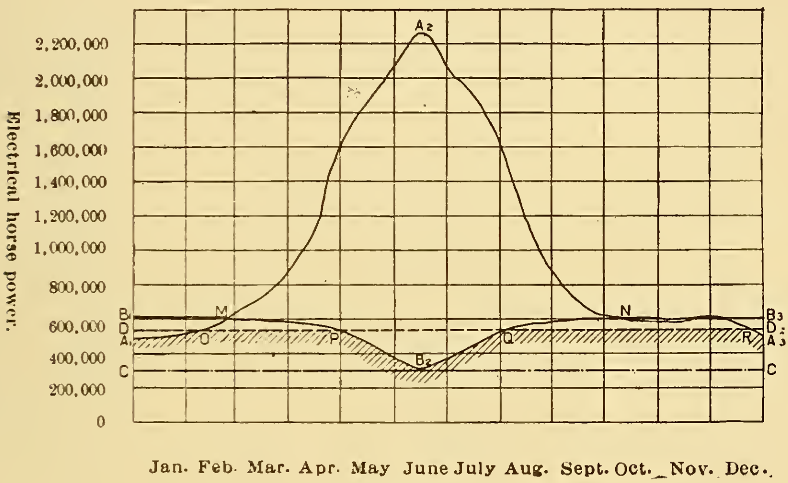


FIG. 5.

During the high water of the summer an immense output for irrigation purposes could be generated by the installation of additional machinery, which would also serve to increase the period of excess power from eight months to about ten months per year. In Fig. 5 is shown a power diagram based upon the average hydrograph of the last ten years shown in Fig. 1, due account being taken of the variation in head occurring during the variation in discharge. In this diagram the line *CC* represents the assumed base load of 300 000 electrical h.p. The line $A_1A_2A_3$ represents the developable power of the stream, which is somewhat deceptive because of the fact of this being an average year. It must be remembered that at times these curves will drop down to line *CC* for as much as several weeks at a time. The line *DD* represents the normal-rated assumed generator capacity of 400 000 kilowatts, or 536 000 h.p., and the line

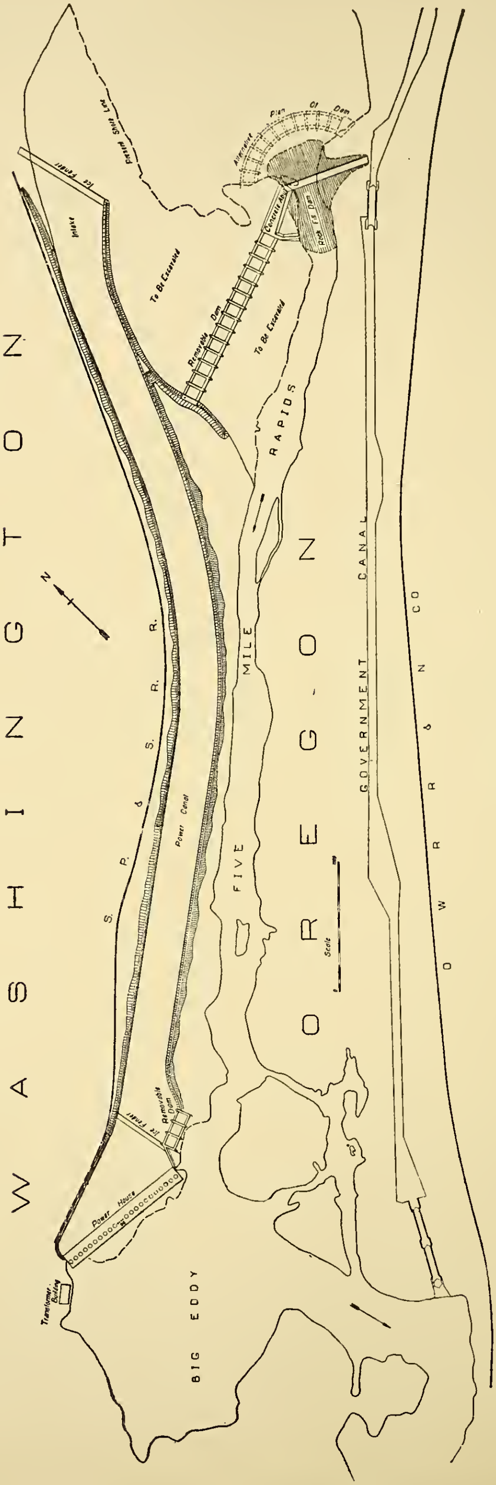

WASHINGTON
OREGON
S. P. & S. R. R.
Power Canal
FIVE MILE RAPIDS
GOVERNMENT CANAL
O W R & N CO
BIG EDDY
Power House
Removable Dam
Ice Fender
Intake
To Be Excavated
To Be Excavated
Present Shore Line
Alternative Plan of Dam
Rock Fill Dam
Scale
N

FIG. 6.

$B_1B_2B_3$ represents the turbine capacity under the fluctuating heads which would obtain. It will thus be seen that under the recommended plan of development the flow of the stream would limit the station capacity from A_1 to O and R to A_3. The generator capacity would limit from O to P and Q to R and the hydraulic turbine capacity from P to Q. The first named limit is the only one which could not be eliminated by the installation of additional machinery.

An immense capacity could also be developed for supplying an irrigation load during the peak of the stream flow shown by MA_2N.

Construction Features. The proposed general layout of this project is shown in the accompanying Fig. 6.

The development of this project requires the construction of a dam at the head of Five Mile Rapids where the extreme fluctuation in water level is about 90 ft. and the usual annual fluctuation about 65 ft., the depth at extreme low water being about 50 ft. to 70 ft. At this point the Columbia River suddenly contracts from a width of about 1 500 ft. to a width of 200 ft. and flows for a mile and a half throughout Five Mile Rapids through this narrow channel of great depth.

The construction of a dam by the unwatering of this site in the minimum depth of 50 ft. of water with an annual probable rise in flood of 65 ft., with occasional rises of 20 to 30 ft. during the remainder of the year, would be an extremely venturesome construction problem. Neither time nor money has been available to make the investigations necessary to choose the proper type of dam for this location, but we have suggested two types of dams which could be built without unwatering the dam site and either one of which is believed to be feasible, subject to further study of the problem. The first plan requires the cutting of a diversion channel to the north of the dam site of sufficient size to divert the entire flood flow of the stream for permanent as well as temporary purposes, for which purpose there would be constructed in this channel some removable type of dam such as the one being used for the emergency dams on the Panama Canal, except with the substitution of a permanent concrete bridge to take the top reaction of the vertical girders instead of the draw span used at Panama.

After the completion of the diversion channel and removable dam the plan would be to deposit in the neck of the rapids large rock in no less than 30 to 50 ton sizes, taken from the excavation and anchored if found necessary, to prevent them from being

carried downstream by the very swift water in which they would need to be placed. Anchorage, if necessary at all, would only be required until the rock fill had risen to such an elevation as to divert the river through the prepared channel. One working season should allow sufficient time to build a rock fill dam to a sufficient height to divert the succeeding flood through the channel and prevent overtopping of the rock fill. After diversion of the river it would be necessary to secure tightness of the dam by depositing successive graded sizes of material on front face until the final layer of clay puddle would be reached. Several rock fill dams of this type have been built, but nearly always in the dry or in very small streams where the distribution of the graded sizes of material over the front face could be accurately governed. In our case it would be necessary to deposit a very large amount of each size of material to insure the covering of the entire surface, most of which would be below water level. We have based our estimate upon a top width of 50 ft. for the rock fill dam, with both upstream and downstream slopes of three to one, and have allowed eighty cents per cu. yd. for depositing this material, together with the allowance of $200 000 for anchorage of the large rock deposited prior to the diversion of the river. This would seem to be an ample allowance both as to cross section and cost to cover any probable contingencies.

The other proposed type of dam would consist of large piers placed by pneumatic caisson process in a semicircular arched position in the shallow water above the neck of the rapids. After placing of the piers in this manner huge specially constructed bulkheads would be placed at the upper and lower points of the piers, shutting off one or more openings at a time for construction of the ogee dam between piers, which would act as a sill for the same removable type of dam as would be placed across the diversion channel in case of the adoption of the rock fill plan.

Except for the hazard involved in construction of this dam, the project involves no special features other than size. In this respect it is unprecedented. The plant of the Mississippi River Power Company at Keokuk, which is nearing completion, is heralded as the largest power plant in the world. There will be installed in this station ultimately thirty units each capable of developing 10 000 h. p. under 32 ft. head, or a total of 300 000 h.p. The minimum head at Keokuk, however, reduces to 22 ft., thus greatly decreasing the power of these turbines. Rated in the same manner as the Keokuk installation, the proposed

station would contain 672 000 h.p., as compared with 300 000 at Keokuk. The proposed station would have a capacity of 300 000 continuous electrical h.p. twenty-four hours of each day in the year, whereas the minimum power of the Keokuk station on the same basis it is believed is not over 100 000 h.p., the additional machinery being needed to carry the peak load at a reduced load factor and also to maintain full power under the reduced head existing during floods. As the proposed station is expected to serve an electro-chemical load, the large additional capacity to provide for full utilization at a low-load factor is not necessary.

Cost of Development and Cost of Power.—Although but a short time has been available for preparing our cost estimates of the project, yet it is believed that they are sufficiently complete and accurate to indicate that this power could be developed and sold at a remarkably low price.

In adopting unit prices for the estimates on this work the size of the work and the resulting special methods of handling of materials which would be warranted thereby have been kept in mind, and it is believed that the work can be done at the assumed unit prices, namely, rock excavation, $1 per cu. yd.; concrete, $7 per cu. yd.; structural steel for removable dam and elsewhere, $90 per ton; and rock and other fill in the dam, 80 cents per cu. yd. Prices of machinery have been based upon tentative figures secured from two of the leading hydraulic turbine manufacturers and from the three leading electrical manufacturing companies, with sufficient margin added to cover changes in market conditions.

In order that quantities might be estimated with a fair degree of accuracy, a plain table survey was made of the canal line and tentative drawings were made of the power house, removable dam, girders, wickets, etc. These quantities would no doubt be subject to some change subsequent to the preparation of more complete plans for the various structures, but it is believed that they are sufficiently accurate for present purposes.

Based upon the above assumed unit prices and machinery estimates and allowing for interest during a four year construction period, 6 per cent. for engineering and legal expenses and a $1 000 000 contingent fund, places the capital investment in the project at $77 per h.p., based upon the 300 000 h.p. capacity which would be available at all seasons and at the switch board.

The annual cost of power has been based upon the following assumptions, namely, the sale of 4 per cent. state bonds without

discount, a depreciation sinking fund assumed to draw 3 per cent. interest and sufficient to replace all machinery and other depreciable parts in fifteen years and all permanent structures in fifty years, an annual fund for maintenance and repairs of $500 000 and cost of attendance and administration of $125 000. On this basis the annual cost of power would be about $6.90 per electrical h.p. year based upon the sale of only the 300 000 h.p. of base load.

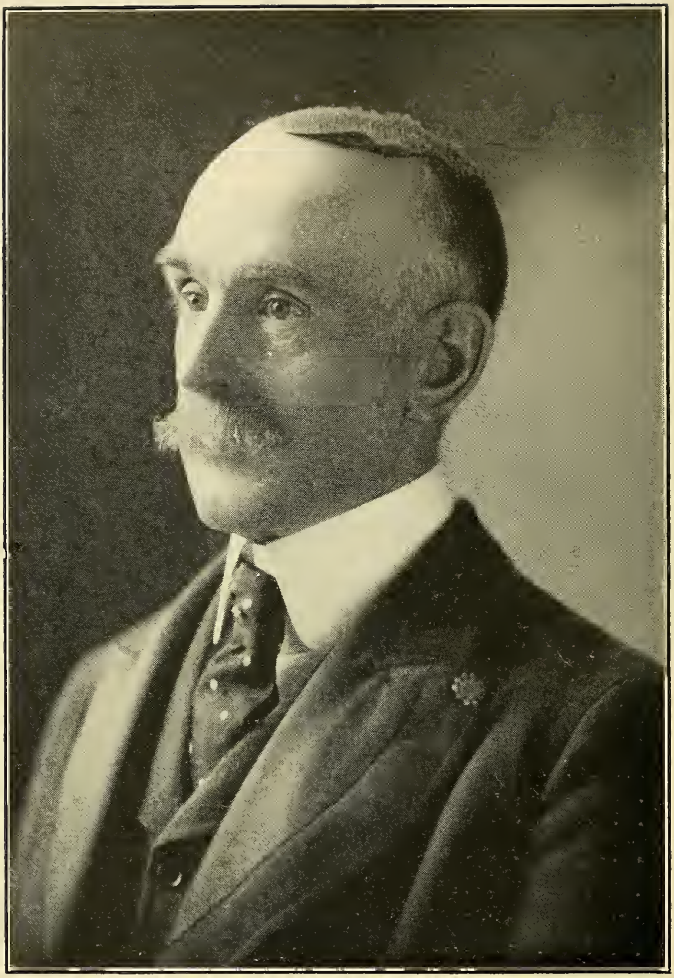
As previously mentioned, this project would require a vastly greater amount of study to arrive at cost estimates sufficiently accurate to warrant the sale of power on a close margin. The price which the representative of the Norwegian Nitrates Company expressed himself as willing to pay, namely, $9 per h.p. per year, is ample margin, however, to warrant the statement that, with reasonable certainty, power can be developed and sold at a price which would make the utilization of this immense water power feasible from a commercial standpoint.

What this would mean to the Columbia River districts of both Oregon and Washington can scarcely be realized. Should the nitrates industry utilize the entire 240 000 h.p. which it contemplates utilizing, its output would be about 165 000 short tons of nitrate per annum. For this would be required barrels, limestone as a raw material, and the transportation of this output by water or rail to the interior and to a seaport for exportation, as well as the transportation by water of limestone to the site for use in the manufacturing process.

One other company has signified its interest in the immediate purchase of 50 000 h.p. of the excess power with an ultimate increase to 150 000. It is thus believed that there would be, in the course of a few years, in this locality an electro-chemical center comparable only with the Niagara Falls and Norwegian districts, and that our West Coast, more particularly the area tributary to this power, would become a manufacturing center of great importance.

The detailed report of this project has been printed as "Bulletin No. 3, Office of the State Engineer, Salem, Oregon," and can be obtained by writing to Mr. J. H. Lewis, the state engineer.

[NOTE.—Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 15, 1913, for publication in a subsequent number of the JOURNAL.]



Edward C. Hollidge.

OBITUARY.

Edward C. Hollidge.

MEMBER CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

EDWARD C. HOLLIDGE, Division Engineer, Soo Railway, died of heart failure at his home in Superior, Wis., January 20, 1913. He was born in Buffalo, N. Y., December 27, 1852. His engineering education he received at Wyall School of Engineering, St. Louis, of which he was a graduate. He was well known in railroad engineering circles, having followed that branch of the profession almost continuously with various railroads since his graduation.

In the early days of the Soo Railway he was on location under G. M. Willis, when the Soo located from Minneapolis to Rhinelander, Wis. On construction he was given charge of the bridge work. When the M. & St. L. Ry. built toward Watertown, So. Dak., he was in charge of location, under the direction of Mr. A. B. Stickney, who until recently was president of the C. G. W. Ry. On this survey he had as assistants Harry Horn, former general manager of the N. P., and Mr. S. C. Stickney, general manager of the C. G. W. Ry. He then left the M. & St. L. Ry. and went into the bridge contracting business together with Mr. F. H. Balduc. The most important contract works which they did were the C. & N. W. docks at Escanaba, Mich., and the bridge work on the C. & N. W. Ry. in Iowa. After completing his contracts he did the engineering work on the Minnetonka and Lyndale line, now a part of the Twin City Rapid Transit system, and together with Mr. Geo. W. Cooley, state highway engineer of Minnesota, the engineering work on Minnetonka Beach.

From 1900 to 1905 he was consulting engineer looking up and reporting on various railway projects in North Dakota, Minnesota and Virginia. In 1905 he was again with the Soo Railway on construction of the Thief River Falls-Kenmare Division. From November, 1905, to October, 1906, he was on location for the D. S. S. & A. Ry. from Duluth to Detroit, Minn. From this latter date he was with the Soo Railway as locating engineer on various lines in the northern part of Minnesota and

Wisconsin. Early in the year 1907 he was appointed division engineer in charge of the construction of the Soo terminals at Duluth and Superior, consisting of terminal yards, depots, dock and wharf construction.

Mr. Hollidge has been a member of this Society since 1909. Besides his wife, Mr. Hollidge is survived by a sister, Mrs. Emma C. Brown, of Minneapolis, and a brother, Mr. Harry H. Hollidge, assistant engineer of the city of San Francisco, Cal.

A. J. RASMUSSEN.

Francis Blake.

MEMBER OF BOSTON SOCIETY OF CIVIL ENGINEERS.

FRANCIS BLAKE, son of Francis and Caroline (Trumbull) Blake, was born in Needham, Mass., on December 25, 1850. He died in Weston, January 19, 1913.

After studying in the schools of Brookline, where he early developed an aptitude for mathematics, he entered the service of the Coast Survey at the age of sixteen. Rapid promotion, both in office and field work, followed, particularly in connection with the astronomical work of the Survey. His marked ability in this specialty led to an appointment to the Darien Expedition; later he became an assistant to Professor Hilgard in France, in computations connected with the determination of the differences of longitude between Greenwich, Paris, Cambridge and Washington. Thirteen years of his life were passed in the government service.

Mr. Blake was an untiring student of physics, and he was, besides, remarkably expert in many kinds of mechanical work. His training and inclination led him to produce inventions which were marvels of thought and skill. Only a few days before his death the writer spent several hours with him, examining his astronomical and meteorological instruments of precision and the observations which were regularly transmitted to the Meteorological Bureau in Washington.

In 1878 he invented the well-known Blake transmitter, which brought him wide fame throughout the civilized world. This device enabled the Bell Telephone Company to make rapid advances.

In 1873 Mr. Blake married Elizabeth L., daughter of Charles T. Hubbard, and later built a handsome residence in Weston surrounded by spacious grounds. The beautiful terrace commands a wide view over the valley of the Charles. There for many years he entertained his friends with warm hospitality.

To the time of his death he was a director in the American Telephone and Telegraph Company, and was also connected with many learned, scientific and social organizations. At their meetings his hearty greetings and cheerful sympathies always brought him a welcome reception.

In addition to the telephone transmitter, Mr. Blake patented many clever electrical devices, and although an invalid for several years before his death, his active mind kept at work in this direction to the end.

It would require a volume to give expression to the large void left in public and private activities by the loss of Francis Blake. It would also require another volume to narrate his many excellent and attractive qualities of mind and heart. In addition to his wide and accurate scientific attainments he was a lover of nature, a generous contributor to charities, a director who gave long and patient service to the duties of office, a public-spirited citizen, a faithful friend and an earnest and untiring worker for the upbuilding of the race.

Desmond FitzGerald, *Committee.*

ASSOCIATION
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ENGINEERING SOCIETIES.

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DISPOSAL OF PAPER MILL WASTES.

BY EDWARD HUTCHINS, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read before the Sanitary Section.]

THE art of disposal of trade wastes has been studied more in Europe than in this country. There, all paper mills at least partially purify their wastes. For this reason most of the available information is of European origin. A large amount of experimenting is being done in America, but it is, as yet, mostly unpublished.

The following paper gives a brief summary of the wastes to be handled, their characteristics and principal methods of treatment, also a brief description of the plant with which the writer was connected until recently.

The first general attempt to better the condition of the rivers in any country, was made in England, and dates from the "Royal Commission on River Pollution" appointed in 1868. The work of this commission resulted in the passage of the "Rivers Pollution Act" in 1876. This law was not properly, or uniformly, enforced by the local authorities charged with its execution. For this reason the law was modified in 1888 so as to take the authority from the local boards and give it to a few commissions especially appointed to enforce the law. It was not until 1890 that all mills were generally forced to care for their wastes. English paper mill plants are, as a rule, of the settling-pond type, where all wastes are mixed together and settled with or without the use of a coagulant.

As far as the writer can learn, no general standards of purification have been adopted, each situation being treated by itself.*

In the United States, the question was first considered in Massachusetts, and in no other state has as much attention been given to the subject.

In Massachusetts the first action looking to the purification of the rivers dates from 1872, when the state board of health was ordered to collect information concerning the condition of the rivers of the state and to report to the legislature. It reported that the rivers were not then polluted enough to cause harm. Nothing was done until 1884, when the "Massachusetts Drainage Commission" was appointed with orders to consider the whole subject and especially to devise means for the relief of the Mystic, Blackstone and Charles rivers.

This commission recommended as follows:

1. That some persons look after the public interests.
2. That they become familiar with the situation.
3. That they stop present pollution.
4. That they prevent future pollution.
5. That they suggest means of disposal to all interested.

"*In a word, it shall be their special function to guard the public interest and the public health in relation with water, whether pure or defiled,* WITH THE ULTIMATE HOPE, WHICH MUST NEVER BE ABANDONED, THAT SOONER OR LATER WAYS MAY BE FOUND TO REDEEM AND PRESERVE ALL THE WATERS OF THE STATE."

The capitals are by the writer.

These recommendations became a law in 1886, and under this law the state board of health has dealt with the situation, except in a few isolated cases, where special action has been taken by the legislature. The law passed in 1890, regarding the clearing of the Neponset River, which law will be mentioned later, comes under this latter class.

At the present time, very little is known about the purification of trade wastes, and this is especially true of paper mill wastes. In the writer's opinion, there will be developed, in the near future, much better methods of treating suspended matter than those now in general use, and ways will be found to treat successfully waste boiling liquors which have not been economically disposed of.

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* Since the above was written the "Royal Commission on Sewage Disposal" has issued a report proposing such standards for England.

The subject of trade wastes is made more difficult by the fact that there are no set standards of purification which can be used as guides by engineers engaged in disposal work. It would simplify the whole problem if it were known, in advance, what amount of purification would be required. No matter how much the manufacturer may be in accord with the idea of a clean river, he does not feel justified in spending any more for disposal works than is necessary to satisfy the public, and he is entirely justified in this attitude. In fact, he is obliged to take this stand because his competitors, being better situated for the time being, do not have to purify their wastes and thus have him at a disadvantage.

With the present uncertainty as to what will be required, the manufacturer usually directs the engineer to spend as little money as possible in getting him out of his difficulty. Thus the most important question the engineer has to solve is the personal equation of those charged with the enforcement of the law. In nine cases out of ten, this results in a plant that may be acceptable for a year or so, but which will not permanently or satisfactorily dispose of the wastes. In this way money is wasted that would have been expended to better advantage had it been known what was required.

It should be the duty of authorities, charged with the purification of rivers, to formulate definite requirements and to inform the manufacturer the degree of purification required. With this information, the manufacturer can ascertain what disposal works will cost and determine whether he can afford to stay on the stream or not.

If, as the "Massachusetts Drainage Commission" states, we are to plan to have pure rivers, then the legislature should define what is meant by a pure river and adopt the standards to which all rivers, now pure, must be kept and to which rivers now polluted shall be brought by progressive stages, these stages to be fixed by the state board of health, or similar body. Thus at the end of a fixed term of years all rivers would be clean and the manufacturer would have distributed the burden over a term of years.

The standard should be a practical one, commercially attainable, which would allow manufacturers to utilize the rivers in the disposal of their wastes so long as the wastes do not pollute the rivers beyond the point where fish can live in the water and the rivers be pleasant for recreative purposes. Two standards might be required, one for the streams used as public

water supplies and another for streams used for manufacturing purposes. We are only concerned with the latter.

Standards of this kind would change the attitude of the manufacturer from one of procrastination and half measures to one of action. He would desire to get what must be done, done and out of the way. He would not ask the engineer how little he could do and escape prosecution, but would instruct him to build a plant to treat his wastes so as to meet the standards, and to keep the expense as low as possible.

The writer knows that such standards are hard to formulate, but there is no reason why it cannot be done, and as a matter of fact such standards have been proposed from time to time. Let the state board of health ask the legislature to appoint a commission to investigate the situation and devise these standards. Let the legislature adopt them and a long step in the right direction will have been made. A similar action to that proposed was taken in the case of railroad grade crossings, and it has produced satisfactory results without too great a burden on any one.

The state board of health should be charged with the enforcement of the standards. They should see that the river waters of the state are brought to the standards as quickly as is consistent with fairness to the manufacturers and that as few of them as possible are forced out of the state. Rivers now polluted should be studied and the state board of health should make a set of progressive standards for each river. After these have been adopted, the state board of health should notify the interested manufacturers that on such and such dates they would be expected to have reached certain stages in the purification of their wastes, the amount of purification to be judged by the condition of the river water below their plants. In this way the standard for these rivers can be gradually raised without asking more of the manufacturer than is reasonable, and without going beyond the known possibilities of the art of waste disposal. The manufacturer will be able to spread his expense over a term of years and the public will know that the rivers will finally be in a satisfactory condition.

Wastes to be Handled.

The manufacture of paper is not carried on in the same manner for any two grades, but the processes are similar and the variations usually consist in omitting one or more of the stages to be mentioned.

The raw material, wood, paper, rags or other stock, is first cut into small pieces and dusted. These operations produce the "solid wastes." The stock is then boiled in an alkaline or acid solution to break down the fiber and to remove grease, dirt, resins, etc. The spent liquors from this boiling produce the "boiler wastes."

The stock is next washed to remove the chemicals and loosened dirt. It is then bleached and again washed to remove the spent bleaching fluid.

The water used in these two operations is called "wash water" and the wastes "washer wastes." They are usually similar to the boiler wastes in composition, except that they are diluted. Washing is usually done in large tubs, in which the stock is circulated. The dirty water is removed continually by means of a revolving wire-covered cylinder, fitted with buckets on the inside. Fresh water is added as fast as the dirty water is removed. The washing is often done in the beating engine. After the washing, and in many cases during the washing, the stock is beaten, — that is, reduced by mechanical means, — to the proper length and condition for the formation of paper. Beating is a cutting, drawing or bruising process, or a combination of all three, depending on the quality of product desired. When the beating is complete the stock has been reduced to pulp and is ready for the manufacture of paper. This stock is then further diluted with water and pumped to the paper machine, where it is formed into sheets by one of two processes. The first is by means of wire-covered cylinders revolving in vats of dilute stock. The water passes through the fine wire cover and the stock is retained on its surface, from which it is removed in a continuous sheet. The second is by means of a horizontal wire cloth belt conveyor, made of fine mesh wire, one end of which receives the dilute stock and carries it forward. The water runs through the wire while the stock is retained on its surface.

In either case the stock is removed from the wire cloth to a woolen carrier belt, called a "felt," which takes it through a series of presses and delivers it in the form of a partially dried sheet to the driers. From the driers it is carried to the calenders, slitter and winder, where it becomes the finished product. The paper is called cylinder machine paper or Fourdrinier machine paper, depending on the type of machine on which it is made.

In the process of forming paper, large quantities of water are used, but fortunately most of this is used over and over again. A certain amount of fresh water has to be added to clean the

felts and wires and to prevent an accumulation of slime and dirt. This added water requires the withdrawal of an equal amount of waste water to keep the vats from overflowing, and this water is known as "machine wastes."

Hence the wastes to be disposed of are of four classes, — solid, boiler, washer and machine wastes. These will be discussed separately and an idea given of the amount and character of the wastes.

Solid Wastes.

The disposal of the solid wastes does not ordinarily cause trouble, as they can be burned as fuel. These wastes vary in amount from nothing in some mills to as high as twenty per cent. of the original stock. The dustings from fibrous material, which may amount to three or four per cent. of the stock and consist of short fibers, dirt, etc., have in some mills been used in connection with liquid wastes as fertilizer. Slivers and like matter from wood mills have been allowed to go to waste, but they are readily saved and either made into pulp or burned with bark and other refuse.

Boiler Wastes.

Many mills do not boil their stock, but those that do are considered under three classes, depending on the treatment given the stock. These are, — rag mills, sulphite mills, soda and sulphate mills. Under the term "rag mill" will be included all mills that use old material such as rags, rope, burlap, old papers and the like, not requiring too drastic treatment of the stock to render it fit for paper making. Stocks of this kind are usually boiled in long horizontal boilers, revolving slowly under a pressure of twenty to thirty pounds of live steam. They are boiled in a solution of lime or caustic soda, or a mixture of both, for several hours, after which the spent liquor is blown off and the boiler emptied.

The amount of waste liquor to the ton of stock varies greatly and depends on two things, —first, on the amount of liquor used in boiling; and, second, on the care with which the liquor is drained away from the boiled stock. It varies from 100 gal. to perhaps 300 gal. per ton of stock and may be said to average about 150 gal.

The quality of the waste liquor varies with the chemicals used and with the stock. As a rule, it is very strongly alkaline and is very badly polluted with dirt, alkaline soaps, etc. Much of the foreign matter is in solution and much of the matter in

suspension is in such a fine state that it will not settle even when using a reasonable amount of coagulant. Filtration will remove only the matter in suspension. There can be no bacterial action due to the strong alkali. Filtration is also difficult from the tendency of fine material to clog the filters. The only way that they have been treated, as far as the writer knows, is by evaporation. Where large amounts of caustic soda are used, the recovery of this by evaporation might make a satisfactory method of treatment, but there are several conditions which make it much less profitable than in the soda process mills to be described later; — in the first place the amount of organic matter in the waste is comparatively small, due to the less severe boiling of the stock, and hence more fuel is required to evaporate the liquor; second, the amount of caustic used is less per ton of product and more wash water is required to remove the dirt; lastly, with the usual small amount of liquor to be treated the apparatus and labor costs are so great that recovery is out of the question. A method of evaporation which has been suggested is to place the wastes out of doors in shallow pools, where they can be evaporated by natural heat. This should make a satisfactory method of disposal for small quantities. Another method is to use them for sprinkling the streets. Where the public will allow this method, it is very satisfactory. The soaps and gums in the waste seem to have the property of cementing the fine dust particles and, in this respect, to act similarly to road oil. The effect, however, does not last as long. Another method of treatment is to combine evaporation and filtration by applying the waste to land so situated that the liquid will partially evaporate and partially filter back to the water course, being diluted on its way by the ground waters. Large areas are required for this purpose, and in time they become clogged so as to be useless for filtration.

It has been suggested that these boiler wastes be used as a fertilizer and this will be well worth looking into, where other means of disposal do not look promising.

The following analysis shows that in some mills there is a large amount of nitrogen which should be valuable.

Analysis of Boiler Wastes, Rag Mill.

Parts per 1 000 000.

Nitrogen	297.3
Potash	0.
Phosphates	0.
Alkali	9 370.

By adding phosphates and the dustings from the rags, this might be made into a fertilizer which would allow the waste to be disposed of without too great expense.

Sulphite Mill Wastes.

The sulphite process is used in the reduction of wood exclusively, and is carried out as follows: The wood is barked and cut into small chips. The chips are fed into large stationary or rotary boilers called digesters. The bisulphite liquor, made by absorbing sulphur dioxide gas in a solution of milk of lime, is then added to the digester and steam turned on. The mass is cooked for about eight hours, under eighty to ninety pounds of steam. The whole charge is then blown into a pit with a perforated bottom called a blow pit. The waste liquor drains away and runs to waste. There is a loss of 250 to 350 pounds of sulphur and about fifty per cent. of the weight of the wood per ton of pulp made. In "Wood Pulp," by Cross, Bevan & Sindall, there is a good résumé of the present state of the art of sulphite liquor disposal. They state that there have been many attempts to recover the sulphur or other by-products, but that no system has yet been introduced for the recovery of the wastes, on a commercial scale, which is likely to be remunerative.

They give nearly a complete list of the patents and suggestions that have been advanced. Many of these produce by-products of some value, but have nearly as bad wastes remaining to be treated as the original liquor.

Among the by-products proposed are: Tanning agents; size for paper and textiles; glue for various purposes, including glue for briquetting fuel; mordant for woolen goods; colors; soap; fertilizers; alcohol, etc.

Hoffman gives the analysis of several sulphite waste liquors as follows:

Analysis of Sulphite Pulp Waste Liquors.

Grams per Liter.

	(1)	(2)	(3)	(4)	(5)
Total solids	82.0	88.0	85.0	93.0	92.0
Loss ignition	68.0	75.0	69.0	81.0	....
Ash	14.0	13.0	16.0	12.0	....
Total sulphur	....	....	....	....	9.2
Free sulphur dioxide	2.6	2.2	2.9	2.6	3.8
Sulphide radicle (SO)	7.3	7.9	6.7	1.2	3.8
Sulphate radicle (SO)	4.1	5.4	4.8	2.7	1.9
Oxygen consumed	52.0	52.0	50.0	60.0	....

Soda Mill Wastes.

The soda process is used in the reduction of wood, straw and other fibers, and is similar to the sulphite process, except in details and in that the reducing agent is caustic soda. Caustic soda is so valuable, and such large quantities are necessary to reduce the fiber, that it is always recovered. Hence these wastes do not pollute the rivers. This is fortunate, as a worse liquor would be hard to find.

In making soda pulp, the wood is prepared as for sulphite, and then put in boilers with 16 to 20 per cent. of caustic soda, based on the weight of the wood. The boiler is a rotary or stationary boiler and the pulp is cooked under 70 to 80 pounds of steam for eight or nine hours. It is then emptied into drainers and the waste liquor drained and washed out. The wash water is kept as low as possible in this process and is treated in connection with the boiler wastes. The limit of wash water and boiler wastes for economical operation is about 1 000 gal. per ton. The combined liquors are evaporated to a thick syrup and finally burned to "black ash," which is an impure carbonate soda. This is made into caustic soda in the usual way by boiling up with quick lime. The clear liquor thus formed is used for the reduction of more wood. The loss of soda in the cycle is about 20 per cent.

This waste can be economically treated because it contains at least 50 per cent. of the original wood in solution and this organic matter supplies most of the fuel needed to effect the evaporation. The evaporation of the weak liquors in this country is done in a multiple effect evaporator and in England by a multiple effect or a Porian evaporator. The thick liquors are burned in a furnace, the heat from the furnace being used to help evaporate the weak liquors.

The successful operation of the plant depends, to a great extent, on the care with which the evaporation, as a heat-consuming operation, is conducted, and the care with which the wash water is regulated.

Sulphate Mill Wastes.

This process is used in the reduction of wood and is similar to the soda process, except that the caustic soda is made from the sulphate of soda, instead of from carbonate. There are also other slight differences. Vile odors are produced in the course of the process, and hence it can be used only in sparsely settled

communities. The waste liquors are always recovered and there should be no stream pollution. The recovery process is similar to that used in soda mills.

Washer Wastes.

Washer wastes vary greatly in composition and amount. Wastes from rag mills will be considered first.

Rag mills that do not boil their stock may wash it, and in this case the washer wastes will have only the dirt in the stock, together with some fiber. Most washer wastes, however, contain the chemicals and other matters from boiling, which cannot all be drained from the stock, as well as more or less fiber resulting from the method of washing. It is not unusual to start the reduction of the stock to pulp during the washing period, to save time and to help dislodge the dirt. The determining of the point at which to stop washing and the handling of the wash water depend entirely on the judgment of the workman. He is apt to use too much water, rather than too little. Where the chemicals are recovered it is customary to treat the wash water with the boiler waste and to limit it to the minimum amount. Where any method of treatment is proposed it would be wise to do this, except where it is desirable to further dilute the boiler wastes.

The amount of wash water may be estimated from 10 000 to 30 000 gal. per ton of paper, and may run higher, depending on the class of stock used and the products required. Washer wastes are usually badly polluted with organic matter in solution as well as in suspension. They require treatment to remove this soluble matter, except where the stream is large enough to effect their purification by dilution at all stages of the river.

In some cases it may be possible to remove the suspended matter and allow the stream to care for the soluble organic matter. It is very difficult to remove all of the suspended matter, even when large amounts of coagulant are used. The usual treatments are by sedimentizing, screening and filtration. The analysis of washer wastes will vary with the mill and the product. The following analysis of rag mill waste is representative:

Analysis of Washer Waste.
Parts per 100 000.

Total residue on evaporation	404.70
Dissolved	148.90
Suspended	255.80

Ammonia free	0.52
Ammonia total	9.53
Dissolved	0.93
Suspended	0.60
Oxygen consumed (unfiltered)	65.65
Alkalinity	5.80
Hardness	74.3

The washer wastes of the sulphite and soda mills are dilute boiler wastes, and should be treated with these wastes where any treatment is attempted. They do not need a separate description.

Machine Wastes.

The machine wastes are the bulkiest of all the wastes, but fortunately they are the least difficult to treat. They contain large amounts of fiber, clay, coloring matter, etc., but do not contain much organic matter in solution or much readily putrescible material.

The machine wastes vary from 15 000 to 50 000 gal. per ton of product, with an average of about 40 000 gal. for cylinder machines and 20 000 for Fourdrinier machines. In many mills this waste can be reduced 50 per cent. by the use of shower pipes designed especially for this purpose.

The machine wastes often contain large amounts of fiber which is unnecessarily wasted. This is due to leaks on the paper machine which could and should be stopped by the operator. These careless losses are apt to be at times larger than the inevitable natural losses.

The usual method of treatment for machine wastes is by settling or straining, and as the organic matter in solution is very small, these methods should be all that is necessary. It is possible by installing the proper system to still further reduce the volume of wastes from a paper mill by utilizing the purified machine wastes in place of fresh water for boiling and washing stock.

The wastes to be handled are then as follows:

Solid Wastes.

Boiler wastes	150 gal. per ton.
Washer wastes	15 000 gal. per ton.
Machine wastes	40 000 gal. per ton.
	55 150 gal. per ton.

Methods of Treatment.

Paper makers have long known that in the manufacture of paper there is a considerable shrinkage of stock. It is only

recently that any of them have realized that a large amount of this shrinkage is preventable. It is now estimated that the preventable loss is from 8 to 15 per cent. of the paper made.

In the last ten years there have been introduced many devices, known technically as "save-alls," for the recovery of fiber, clay, etc., from paper mill wastes.

These save-alls are of various kinds and may be divided into the following classes:

A. Screening save-alls.
  1. Rotary.
  2. Stationary.

B. Settling save-alls.
  1. Continuous.
  2. Intermittent.

Fig. 1 is a diagram of a screening save-all of the rotary type, which has been more generally used by paper mills than any other type. It is one of the first types of save-alls developed and is similar to the vat on a cylinder paper machine.

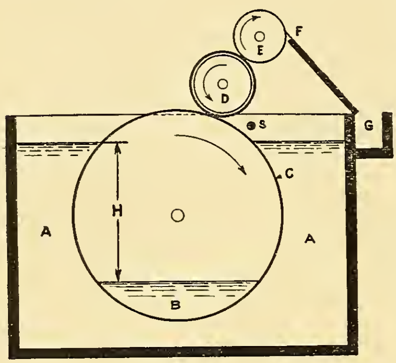

FIG. 1.

The waste water to be treated is introduced into the vat *A*. The cylinder *C* is covered with a fine wire cloth and rotates in the direction shown. The cylinder is open at the ends and has packings which prevent the water in *A* from passing around the ends. The size of the brass wire cloth varies from 60 to 100 meshes to the inch. The water in *A* passes through this wire mesh and escapes through openings in the ends of the vat made especially for this purpose. The meshes of the wire being small, catch some of the fiber and clay in the waste water and carry it up out of the water and under the roll *D*. This roll is covered with a felt jacket, which has the property of picking up the material from the wire and transferring it to iron roll *E*, from which it is doctored by the blade *F*. The distance *H* between the level of the water in the vat and the level of the water flowing out of the cylinder is called the suction, and by regulating the amount of suction the operator has some control over the amount of stock saved.

The trouble with all save-alls of the straining type is to keep the wire clean. A dirty wire will not allow the water to pass through, and hence renders the save-all useless.

In the type of save-all illustrated, the shower pipe *S*, being outside the cylinder, has a tendency to fix any fiber and dirt, not picked up by roll *D*, more firmly on the wire.

Another trouble with save-alls of this type is caused by the impracticability of driving the cylinder *C* and the roll *D* at exactly the same speed. If this is not done there is a strain put on the wire cloth, which it is not strong enough to resist. It first stretches, then wrinkles and cracks to pieces. As soon as it becomes cracked the save-all is worthless. This makes the machine expensive to maintain and far from being fool-proof.

The saving that can be accomplished varies greatly, depending on the amount and quality of stock in the waste water. The saving with the ordinary waste water will not be over 20 per cent., and if there is only a small amount of stock in the waste water, it will drop to 10 per cent. or less. A machine of this kind is valuable mainly as a leak detector. As a save-all it is inefficient, expensive in maintenance, difficult to keep clean and has a small capacity.

Fig. 2 illustrates a similar type of machine, designed to avoid some of the troubles experienced with the type shown in Fig. 1.

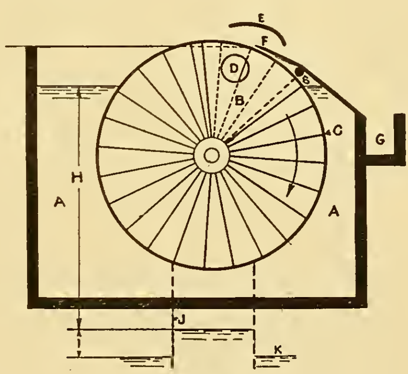

FIG. 2.

In this machine the cylinder is divided by longitudinal plates, radiating from the center into a series of separate compartments. At each end a brass plate *B* fits against the ground ends of the cylinder. In the brass plate *B* on one end is the opening *D*, which is connected with a pressure blower, and as each compartment passes by the opening *D* the air pressure inside the compartment lifts the stock on the wire high enough to clear the doctor *F*. The stock is admitted to the vat *A* and the water runs through into the compartments and out at the ends of the cylinder. The suction for the pressure blower is connected inside of the vat in such a way as to produce a partial

vacuum in the compartments of the cylinder not covered by the plate *B*, thus increasing the capacity of the wire to pass water.

In order to maintain this partial vacuum it is necessary that the outlets for the clear water should be sealed. In this machine the suction is measured by *H* plus 2*I*. This machine is easier to keep clean than the one shown in Fig. 1, on account of the air blast which tends to force all material off the wire and keep it clean. This, however, does not keep the wire entirely clean and the shower *S* is used to aid the air blast. This shower tends to fasten any dirt, which it does not wash off, more securely on the wire.

Machines of this type have been used mostly for treating machine wastes, and although they are not more efficient than the first type described, they are more readily kept clean. Due to the absence of strain on the wire, they are cheaper to maintain. Size for size, its capacity is about double that of the first type.

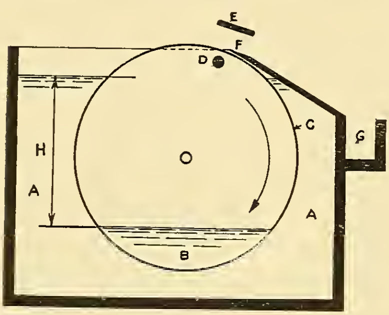

FIG. 3.

Fig. 3 illustrates another save-all similar to the last and only recently perfected. It is simpler, more fool-proof and nearly as efficient as those already discussed. In operation this save-all is similar to the last, except that by a peculiar construction the cylinder is built without internal ribs and the shower pipe *D* is maintained inside the cylinder in such a position that it washes the stock on the cylinder over the doctor *F*. This cylinder is kept clean more easily than either of the first two types. Its capacity on machine wastes is at least four times the first type and two of the second type, due to the better cleaning of the wire made possible by this construction.

In all save-alls shown so far, the amount of suction does not affect the capacity to any great amount. The stock forms on the wire when it first enters the water and when it reaches the position of maximum pressure the wire is so covered with stock that little water passes through the wire.

Fig. 4 shows still another type of screening save-all. In this case the cylinder *C* is covered with a very coarse wire and serves as a support for the traveling felt (endless woolen blanket) which passes in the direction shown by arrows. The water

passing through the felt leaves the stock on its surface, and due to the fine mesh of the felt it collects a large percentage of the waste in the water. The felt is passed through the rolls *E* and *F*, which removes some of the water and breaks the connection of the stock and felt. The stock falls off and the felt returns to a washing box *D* to be cleaned, and then to the cylinder to collect more material. The trouble with this save-all is caused by the great difficulty of keeping the felt clean. This type is useful on clean stock without much clay, but with dirty stock it is impossible to keep the felt clean enough to pass water.

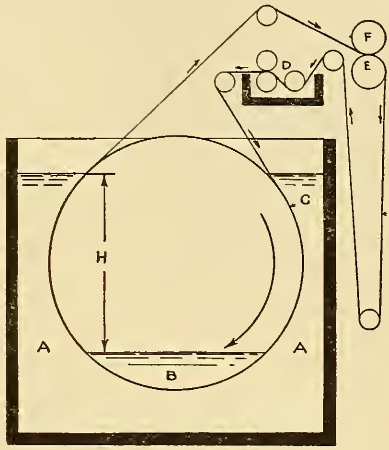

FIG. 4.

Fig. 5 is still another screening save-all of the rotating type. The cone *C* is covered with a fine wire cloth, the whole being rotated by means of a pulley *B*. The waste water enters through the pipe *A* and the water passes out through the wire cover while the stock gradually flows to the open end and into a collector at the point *D*. This machine has been used to quite an extent and is valuable where there is considerable long fibered stock to be caught. This save-all has a large capacity. The shower is placed on the outside of the cone in such a way as to keep the wire practically clean.

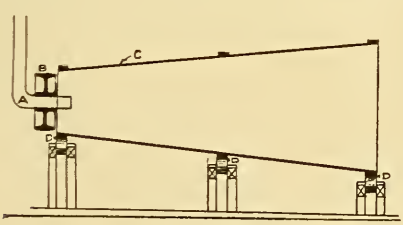

FIG. 5.

Fig. 6 is a straining save-all of the stationary type. In principle it is very similar to save-all shown in Fig. 5. It consists of a square frame covered with a fine mesh wire cloth *C*, under which the reciprocating shower *B* is kept running, in order to clean the wire. The waste water enters the top at *A* and flows by gravity down over the screen *C*. The water runs through the screen and the stock gradually works its way down to the

trough *G*. This save-all has a high capacity and is nearly as efficient as any wire-cloth-covered save-all. This save-all has been mounted in the form of the frustum of a cone, with the waste water delivered at the top, and the saved stock collected in an annular ring at the bottom. This construction is incorrect, and if this type of save-all is to be mounted in a conical form, it should be arranged as an inverted cone. The waste water should be delivered to an annular ring at the top and flow down the inclined conical screen to the center, where the good stock could be collected in a pipe. The reason for this construction is that most of the water escapes in traveling the first one-third distance from the top, and by increasing the amount of wire near the top one gains a large increase in capacity with no increase in space occupied.

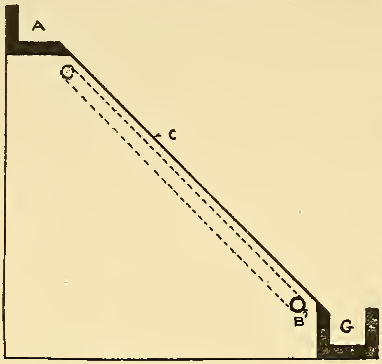

FIG. 6.

The foregoing types illustrate the principal straining save-alls on the market.

Turning to settling save-alls, we find that there are many types; in fact, nearly every one who has attempted to settle stock has developed some differences in the type of tank or pond used.

Fig. 7 represents one of the most used types of settling save-alls in this country. It consists of a conical shaped tank, built of plate steel and supported on cast-iron columns. At the top it has several rings for directing the flow of the incoming and outgoing waste water. The waste water to be treated is pumped into the annular ring *A*. This ring has a perfor-

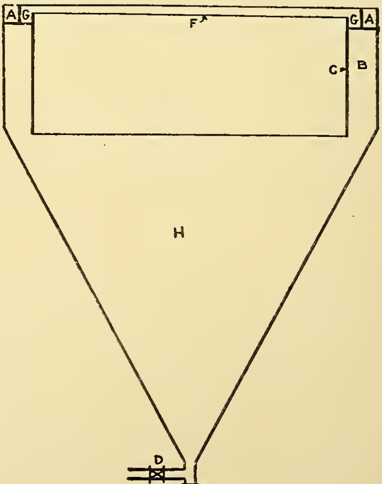

FIG. 7.

ated bottom, through which the waste water flows to the space *B*. The water then passes into the main body of the tank, where it is allowed to settle. It then slowly rises through the central portion of the tank and overflows the rim *F*, into the annular ring *G*, which connects with an overflow pipe. The sludge collects in the bottom of the cone and is drawn continuously back to the paper machine, through the valve *D*. The valve *E* is a clean-out valve. This tank can be used with or without a coagulant and is very efficient with heavy stock. There are several objections to this type of tank, especially where fine papers are made. The material in the tank tends to collect on the surfaces and later break away in large flakes. These flakes are very objectionable on the paper machine, as they make specks in the paper. The tank cannot be readily cleaned, due to the annular rings. When used for settling machine wastes where foamy stocks are used, this foam accumulates on the top, overflows the sides and carries to waste a lot of good stock. The perforations in the bottom of the annular ring *A* do not seem to give the proper distribution of flow. The flow, being concentrated in certain lines, destroys part of its efficiency. For ordinary stocks, a save-all of this type, when run at its rated capacity, can be expected to save 50 to 60 per cent. of the stock in the waste water.

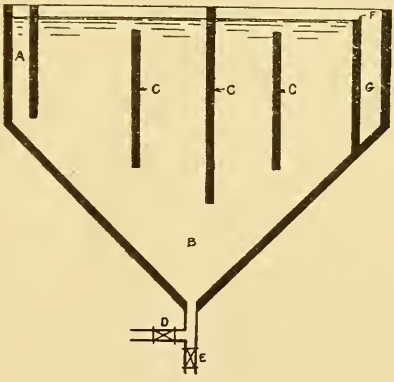

FIG. 8.

Fig. 8 illustrates another type of settling save-all, which is claimed to give as good or better results than the type illustrated in Fig. 7.

This type can be built of reinforced concrete or of lumber, which is an advantage where it is absolutely necessary to prevent iron rust entering the stock. This type is built square or oblong and the partitions seem to have the property of coagulating the fiber in the waste water and causing it to settle.

Fig. 9 is a save-all of the conical type, built entirely of wood, with the exception of the distributing pipes *B*. The outside tank is an ordinary wood stave tank held together with hoops. The annular ring *G* is also made with hoops and staves. The waste water enters at *A* and is distributed by six radiating pipes

B. The overflow ring is at *F* and the saved stock is returned continuously from the bottom the same as in the two previous designs. The inclined staves are held by hoops stapled to the wood. This tank was designed to have as few places for stock to collect as possible, but has two defects which render it if anything less efficient than the previous types. The entrance velocity at the end of the pipes is excessive and disturbs the settling action. The second defect is structural and due to the space *C*, in which the water becomes foul. It is possible to build this tank with only the incline staves.

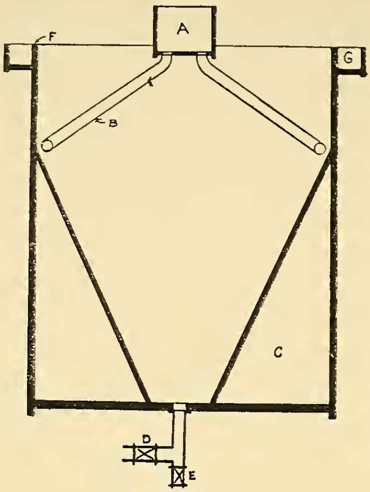

FIG. 9.

Fig. 10 illustrates the latest type of settling save-all of the continuous-flow type to be introduced into paper mills, and has not been used in this country, as far as the writer knows. It has been extensively introduced in Europe. It is obviously more scientifically designed than the previous tanks, although one hesitates to believe the extravagant claims made in its behalf. The waste water enters at *A* and passes down through the throat *H* into the expanding pipe *C*, and at the bottom of this pipe the water turns upward and overflows the rim at *F*. There are few places to collect stock in this tank, and in theory it is different from previous tanks. When the water starts upward from the bottom of pipe *C*, it has a considerable velocity. This velocity decreases continuously as the water nears the overflow rim. As the velocity decreases, more and more particles become able to

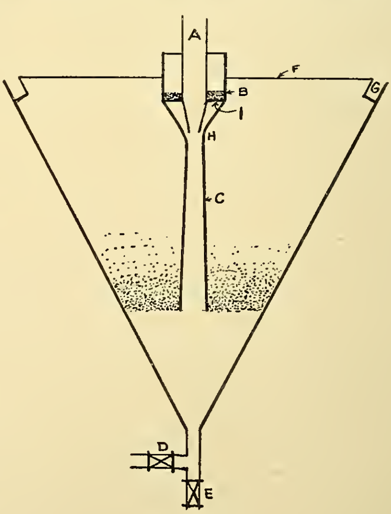

FIG. 10.

sink against the upward velocity and these particles form a mat in the tank, which acts as a strainer and tends still further to relieve waste water of its fiber and clay. When this material has coagulated into heavy particles, it is able to sink through the high velocity at the end of the pipe *C* into the lower part of the cone and is returned continuously to the paper machine, through the valve *D*. Alum cake is put in the basket *B* and the suction caused by the throat *H* causes water to flow through the alum. The larger the volume of waste water flowing, the more suction at *H*, and hence the more coagulant dissolved and used.

The settling save-all which has been used more than any other is the settling pond. This is built either above or below ground and is either worked continuously or intermittently. The trouble with this type of save-all, from the paper makers' point of view, is the difficulty of removing the fiber and clay from such settling ponds. The ponds have to be drained and the material shoveled out by manual labor. This is expensive, and the material is not in a satisfactory condition to use on a paper machine, but has to be worked over in the beaters.

Paper mill wastes are treated by filtration and evaporation. Filter beds for paper mill wastes are built similar to those for sewage. There has been little done in the line of filtration and no rules can be given for the construction of beds. The surface of the bed, and probably the whole bed, can be made of coarser sand than for sewage. The beds have to be cleaned often and will need frequent renewals of the top sand. Sewage, where available, can be mixed with the wastes and in this way some bacterial action can be obtained. Paper mill wastes, as a rule, are sterile and would not by themselves plant the beds. Trickling filters might be used, but as far as the writer knows there have been no satisfactory experiments with them. It is feared that they would be too expensive to maintain, due to clogging with fiber.

The evaporation of paper mill wastes is usually done in a multiple effect evaporator to save fuel. The recovery process for caustic soda in the soda and sulphate mills is quite simple but requires a large expenditure for apparatus and maintenance. The multiple effect evaporators are very hard to keep clean. The furnace for burning the thick liquors has to be very hot and is hard to maintain.

Description of the Disposal Plant of F. W. Bird & Son, East Walpole, Mass.

In 1890 the Massachusetts legislature passed a law requiring the cleaning up of the Neponset River. The paper mill of F. W. Bird & Son is on this river, and so came under the action of this law. The enforcement of this law was placed in the hands of the state board of health. They gave advice to the manufacturers on the river and urged them to purify their wastes. Since the passage of the law, all parties dumping waste into the stream have been working on purification works.

The writer was connected with the Bird plant from the summer of 1906 to the fall of 1911 and had charge of the construction of the plant. The disposal plant is a development of the ideas of the people interested in its construction, and can be said to be no one person's conception. It has been worked out in the main by Mr. Charles S. Bird, Sr.; Mr. Harrison P. Eddy, consulting engineer; Mr. W. E. Sumner, chemist for the company; and the writer.

Mr. Erastus Worthington, of Dedham, Mass., previously to 1907 worked out plans for a complete disposal plant, and these plans were approved by the state board of health. These plans were never followed in detail, although the general method of treatment has not been changed, nor the location of the filter beds. The changes do not reflect on Mr. Worthington's plans, but are the result of tests carried on after he ceased to be connected with the problem.

The mill at East Walpole had five machines, two of which were used for the manufacture of roofing felt. Early experiments on the wastes from this paper proved it impracticable to handle them at a reasonable expense. For this reason the manufacture of felt was discontinued at East Walpole and a mill built out of the state to make this product.

The two felt machines were taken out and a large cylinder machine put in their place, hence at the present time there are four machines, — two ninety-inch cylinder machines, one one hundred and twenty-inch cylinder machine, and one ninety-inch Fourdrinier machine. These machines make a variety of roofing, box and special papers, none of which is required to be absolutely clean and many of which are what are known as coarse papers.

The combined product of the four machines is from 75 to 80 tons daily.

The machine wastes from two machines were being settled in conical save-alls, at the time the writer took charge of the work. Experiments were made on these tanks at various rates of flow and it was proved that with the stocks used in this mill 50 to 60 per cent. of saving was all that could be expected, and that the behavior of the tanks was erratic, that is, they did not give as good results some days as on others. We could find no reason for the variation unless it was caused by slight differences in flow and current distribution throughout the tank. These tanks were made of iron and gave trouble by scaling and sliming. They were hard to clean, and in places around the annular rings it was impracticable to even attempt to clean them. As a result of this the writer constructed two tanks similar to those shown in Fig. 9. These tanks were made of wood for cheapness and were designed to be readily cleaned. They, however, did not give any better results as far as settling was concerned.

About the time these save-alls were put in operation the idea of intermittent settling was suggested by Mr. Sumner, and because this looked so promising tests were not carried on to determine the amount of settling which could have been obtained from these tanks. The laboratory tests on the intermittent system of settling seemed to show that almost perfect results could be obtained by this method. To test this practically the tanks last mentioned were used experimentally as intermittent tanks and the results bore out the conclusion made from laboratory tests.

In the meantime an exhaustive search was made for suitable land for filter beds on which the washer wastes could be treated. Although there is a large amount of gravel in the vicinity of East Walpole, it was found that very little of it was suitable for filter bed construction. No place could be found with the gravel in place, ready to construct filter beds, and it was at last decided to place them near the mill as shown in Fig. 12. It was decided to construct two filters — 1 *F* and 2 *F* — and two sludge beds — 1 *S* and 2 *S*, — and from their action to determine how many beds would be required to treat the entire washer wastes of the mill.

Three 5 000 gal. tanks were erected at *E F G*, as shown on Fig. 12. Two of these tanks are used as preliminary settling tanks and one as a dosing tank for the filter beds. The amount of washer waste from the mill is about 300 000 gal. in twenty-four hours. Due to irregularities in washing, the rate of flow is very irregular.

Each of the filter beds, 1 *F* and 2 *F*, contains 13 500 sq. ft. of filter surface, or one-third acre, and each sludge bed 6 000 sq. ft. They are under drained by two lines of 4-in. drain pipe running longitudinally. The under drainage system is so arranged that the effluent can be returned directly to the pond from each bed,

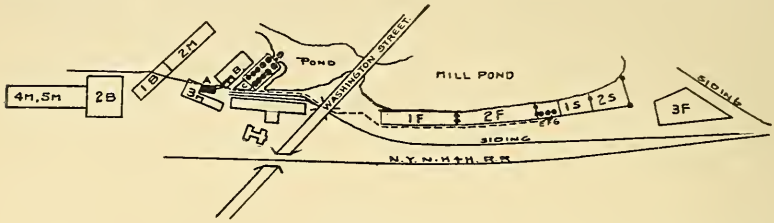

FIG. 12.

or it can all be sent to the lower end of the beds, where it enters a sewer connecting with the river below the pond. The filter and sludge beds are four feet in depth and composed of graded material. Bed No. 1 has three feet of cinders and a top coating of sand one foot thick. Bed No. 2 is an all sand and gravel bed. Both sludge beds are made of three feet cinders with one foot sand on top. So far there has been no difference in results from these beds. All the washer wastes are collected in a settling basin at *A*, as shown in Fig. 12. From this they are pumped to the tanks at the filter beds by two vertical centrifugal pumps in a corner of the store house *B*. The waste is delivered to the settling tanks, one half going to each tank. These tanks are circular wooden tanks, 20 feet in diameter and 20 feet high with slightly conical bottoms. They are provided with an overflow ring at the top. From these two tanks the effluent flows to the dosing tank, which is provided with an automatic syphon which delivers a tankful to one of the beds each time the tank is filled. The filter beds have been dosed once a day at the rate of 300 000 gal. to the acre, and it is found that they need cleaning about once in two weeks. The sludge from the settling tanks is emptied on the sludge bed about once in two weeks. The outlet pipe from these sludge tanks is 12 in. in diameter and with a 20-ft. head. The sludge, after collecting more than two weeks, has been so thick that it plugged the pipe. The sludge contains a lot of fiber and clay but cannot be used on account of the alkali and dirt which it contains. It is possible that mills making the coarsest kind of paper might use this material, but otherwise it must be burned or carted away and used as filling material on waste land.

The effluent from these beds is very clear and has been purified to a large extent, although there has been little bacterial action in the beds. The beds show no signs of clogging from the colloidal matter, which is present in the washer waste.

The experiments on intermittent settling of machine waste having proved satisfactory, it was decided to build six tanks and try it on a large scale. These tanks are shown in Fig. 11 and were constructed with reinforced concrete base and wood stave sides, the joint between the staves and the concrete being made of asphalt cement. These tanks have proved that this is a satisfactory method of construction. These tanks are located as shown on Fig. 12 at *D*. They are the six small tanks nearest *C*.

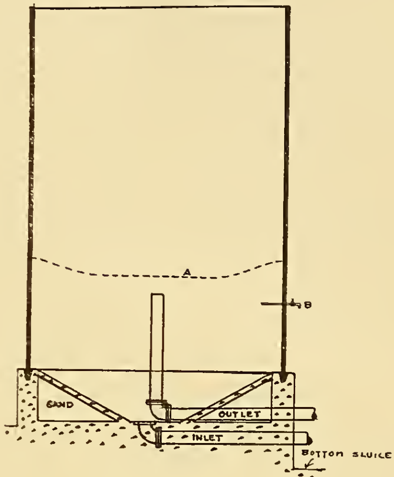

FIG. 11.

The machine wastes are collected by a sewer and brought to large pumps in the corner of the building *B*, which pump it through building *C* into the bottom of one of the settling tanks. In the building *C* the alum which is used as a coagulant is mixed and added to the wastes before they go to the tanks. As soon as one tank is filled to the top, the valves are changed and the waste water is pumped into another tank. The first tank is allowed to settle quietly until the fiber and clay have settled below the top of the outlet pipe. This is evidenced by the operator's obtaining clean water through the tap *B*, Fig. 11. The time of settling varies with the amount of coagulant used, with the character of the wastes from the paper machine and with the outside temperature. It varies from $1\frac{1}{2}$ hr. to $3\frac{1}{2}$ hr. The resulting effluent, however, is always clear and sparkling and contains so little material in suspension that it is invisible in an ordinary quart jar. Although the machine wastes may be quite highly colored, the clean water is only slightly tinted. The sludge from these tanks is removed after every fourth filling, as this has been found by experiments to produce the quickest results. Old sludge which is left in the tank has the property of mixing with the new waste water and aiding in the settling of the

whole. Too large an accumulation of sludge occupies so much room it does not settle below the top of the outlet pipe.

The material in the waste water settles in a definite order. First, the heavy particles come down, then the finer ones, and lastly a jelly-like mass, very thick and very fine, comes down in a sort of a mat across the entire surface of the tank. Just above this thick mass the water is clear, as previously stated. This mass comes down quickest in the center, producing a surface curve, as shown by the dotted line *A*, Fig. 11.

The attendants who control the valves admitting waste water to these tanks and emptying them can tell by the appearance of the liquid from the test valve when the settling period is nearly over. It has been proved that the amount of alum necessary to treat machine wastes in these tanks is slightly less than that shown by laboratory tests. This is probably due to the straining action of the thick jelly-like mass as it comes down.

The boiler wastes at this plant only amount to 1 800 gal. a day, and are used to sprinkle the streets. It is not possible to treat these wastes economically, and, although there is considerable odor from them when put on the street, they are so satisfactory in keeping down dust that the general opinion is in their favor. All solid wastes are carted away to form fertilizer or burned in the boiler room.

The original six intermittent settling tanks did not prove capable of caring for the wastes from the machines.

Four more tanks have been constructed, making six 50 000 gal. and four 75 000 gal. tanks taking care of the water from four machines, or about 3 400 000 gal. in twenty-four hours.

The filter beds have not proved large enough and more will have to be built this year to take care of the washer wastes. The total force handling this plant including the filter beds, the intermittent tanks and the teaming of the boiler wastes is about six men.

NOTE. — Since the above description of the Bird plant was written, the following changes have been made:

Two new settling tanks, one and thirty-one hundredths acres of filter beds and one-half acre of sludge beds have been added.

In operating the machine waste settling tanks, the men now remove the sludge only when necessary to empty a tank to receive raw wastes. They then pump out sludge enough to bring the clear water down to the top of the draw-off pipe.

In this way they are sure to get a concentrated sludge and to use as little as possible back on the paper machines.

The General Summary of Treatments and Conclusion.

There are four principal wastes from a paper mill:

1. Solid.
2. Boiler.
3. Washer.
4. Machine.

There are five principal methods of treatment:

1. Screening.
2. Settling.
3. Filtering.
4. Evaporating.
5. Diluting.

These may be applied to the combined wastes or to the individual waste. The solid wastes can all be burned for fuel and some can be used for fertilizer as stated. This subject of fertilizer is one that should be carefully studied, where boiler wastes high in nitrogen must be disposed of. In some cases it would undoubtedly be the best method available. This is only true where there is a distinct saving in this method over all others, as the cost of marketing the fertilizer and overhead charge is considerable for the amount of product.

The boiler wastes contain so much chemical, so much dirt in suspension and solution, that they are best treated by evaporation with or without recovery. Where recovery is too expensive the only treatments remaining are natural or artificial evaporation and dilution.

Natural evaporation in especially prepared beds or on the roads is practical and in non-thickly settled regions should be satisfactory. If the stream is large enough to care for these wastes by dilution, it is probably most satisfactory to treat all other wastes and let the stream care for this one. Natural evaporation will require about 1 500 sq. ft. of area per ton of product. These beds must be located where the odor will not be offensive to residents. If artificial evaporation becomes necessary, about 26 pounds of waste can be evaporated per pound fuel. This is too expensive, however, for most mills to stand and they had better move to larger streams.

The treatment of sulphite wastes at a reasonable expense is impossible on a large scale with our present knowledge of disposal.

Washer Wastes in Rag Mills.

The screening of this waste is not of any particular value because the fine material will pass any mesh wire and because it is practically impossible to keep wires clean enough to handle the waste. These wastes can be settled and this should be done before any further treatment is attempted. The settling does not remove the matter in solution, nor does it remove all suspended matter. The use of coagulants to bring down this fine suspended matter is usually too expensive.

If the stream is not large enough to take care of the washer wastes by dilution, then filtration is the most practical method of further treatment. Filtration preceded by sedimentation will remove all of the matter in suspension and some of the matter in solution. It can be filtered on slow sand filters with good results, at rates from 200 000 to 400 000 gal. per acre, depending on the condition of the waste.

If bacterial action is needed to remove the matter in solution the wastes must be mixed with sewage to give the bacteria needed to plant the beds. It must also be carefully watched to see that the alkalinity is not great enough to kill bacteria. Mechanical filters are too rapid in their action and will not produce as satisfactory an effluent as slow sand filters. The cost of the necessary coagulant will be excessive and there can be no bacterial action. Washer wastes from sulphite, soda and sulphate mills contain too much organic matter in solution to be satisfactorily filtered without the addition of large volumes of sewage. This sewage is often hard to obtain.

Machine Wastes.

These wastes contain very little organic matter in solution and contain much material perfectly suitable for the manufacture of paper, in suspension. For this reason they should be treated by themselves so that the recovered stock can be immediately used again in the manufacture of paper. As a general rule, the paper manufacturers have found that the recovery of this material is a profitable operation and are putting in machines and tanks of their own accord. In some cases it has been customary to mix the washer wastes and the machine wastes. This is

not advocated because the dirt which is in the washer wastes detracts greatly from the value of the stock recovered from the machine wastes.

It is desirable to keep all stock possible on the machines and keep the machine wastes as small as possible. For this reason it may be very desirable to install a rotating screening save-all as leak detector on all paper machines, and to use shower pipes of the improved type, which use comparatively little water.

The machine wastes should be settled and the stock recovered. More stock can be saved by the intermittent save-all than by the continuous-flow type. On the other hand, the labor cost of the latter is much less. The type to adopt depends largely on the size of the stream and the value of the raw stock used.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the Journal.]

MISSISSIPPI RIVER HIGH DAM AT ST. PAUL AND MINNEAPOLIS.

By Adolph F. Meyer, Member of the Civil Engineers' Society of St. Paul.

Following Captain Freeman's eloquent closing remarks in which he eulogized the American mechanic, what I may say on the "High Lock and Dam" will probably appear quite matter-of-fact. My comments will relate mainly to matters of design connected with this project and to a study of the amount of power which will be made available by the construction of the Government Dam.

Work on this project, for the period covered by this paper, was done under the direction of Major, later Lieut.-Col., Francis R. Shunk, Corps of Engineers, U. S. Army, with Mr. Geo. W. Freeman, principal assistant engineer in local charge.

Lock Floor.

One of the most interesting features of the design of this project is the lock floor.

In the early plans submitted for the construction of a lock of about 13 ft. lift at the site of the present structure having a lift of about 35 ft., a floor laid with open joints was contemplated. The foundation material being porous sand and gravel, a certain amount of water would, in any event, leak past the cut-off wall at the head of the lock, and those concerned with the design of the structure were unanimous in recommending an open floor so that this leakage might be free to escape without producing pressure under the floor. The reviewing Board of Engineers, however, was of a different opinion, and recommended instead a tight, underdrained, concrete floor $3\frac{1}{2}$ ft. thick, reinforced transversely with one square inch of steel every 6 in. and longitudinally with one square inch about every 3 ft. This amount of reinforcement in the direction in which the floor would act as a beam amounted to less than one half of one per cent. of the area of the concrete and it was apparent that the strength of the beam would depend upon the elastic limit of the steel. The floor was built in accordance with the recommendation of the Board of Engineers, square, cold-twisted lug bars, having an elastic limit of 38 000 lb. per sq. in. before twisting, being used for reinforcement.

In 1910 Congress having passed a law requiring provision for a depth of 6 ft. of water on the lower miter sill at low water instead of 5 ft., as originally contemplated, and providing for an increase in the height of the lock and dam to permit the development of water power, it became necessary to remove this reinforced concrete lock floor and to replace it with another about 5 ft. lower. Before entering upon the demolition of the old floor, a test was made for the purpose of determining the amount of under pressure which this floor could withstand. There being a steel sheet piling cut-off extending around the lock chamber under the river wall, and the upper and lower miter sills, and the water outside of the lock standing at an elevation $10\frac{1}{2}$ ft. above the bottom of the lock floor, it was a comparatively simple matter to produce pressure under the floor by pumping water into the twelve lines of tile under-drains connected to a tunnel leading to a sump well. The day before the test was made, sufficient water was pumped into the under-drainage system to completely fill it. Then additional water was pumped into the well until it stood at an elevation of $9\frac{1}{2}$ ft. above the bottom of the floor, almost equal to the elevation of the water outside of the lock chamber. This head was maintained practically undiminished through the night. The next day the pressure was gradually increased until the water in the well stood 15.7 ft. above the bottom of the floor. The test consumed about one-half hour and practically the entire head was transmitted almost instantaneously to the upper end of the lock, about 325 ft. from the well and 6 ft. from the nearest drain. In view of the fact, however, that, after a head of about 10 ft. had been applied, the floor showed appreciable deflection, this rapid transmission of pressure cannot be attributed entirely to the under-drainage system. The upward deflection of the floor at the center was taken at two points, one about 75 ft. and the other about 280 ft. from the upper end of the lock. The head under the floor was measured by noting the height to which the water rose in a hose connected to a pipe driven through the floor.

It appears from the accompanying curves (Fig. 1) that yielding occurred when an upward pressure of about $12\frac{1}{2}$ or 13 ft. of water had been applied. My original computations gave the ultimate load as equivalent to a depth of $14\frac{1}{2}$ ft. of water. Inasmuch as this was based on an assumed elastic limit for the reinforcing steel of 55 000 lb. per sq. in., and inasmuch as the steel used was supposed to have an elastic limit of only 38 000 lb. per sq. in. before cold twisting, it will be noted that the

ultimate load shown by the test agrees substantially with the ultimate load computed by the use of the standard beam formulas. Assuming the weight of a cubic foot of concrete as equal to 145 lb., the $3\frac{1}{2}$ ft. floor would, by its weight alone, withstand an upward pressure of a little over 8 ft. of water.

Fig. 1 shows the total head of water under the floor and also the load carried as a beam, together with the stresses in the concrete and the steel on the assumption that the coefficient of elasticity of the steel was 30 000 000 lb. per sq. in., and that

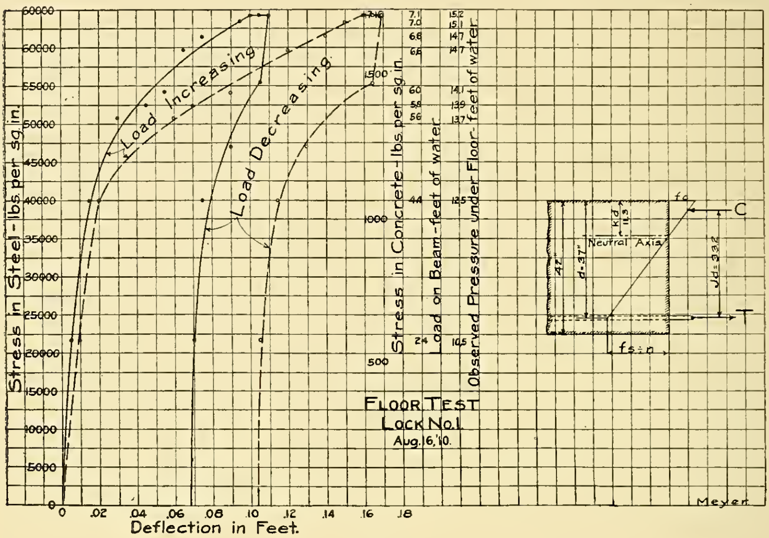

FIG. 1.

for the concrete, 2 000 000. Should these values be assumed as 30 000 000 and 3 000 000 respectively, the stress in the steel would be reduced 2% and the stress in the concrete increased 16%, due to the shifting of the neutral axis to within 9.53 in. of the compression face. I believe that this latter assumption is more nearly correct than the former.

The curves for decreasing load have the familiar shape characteristic of deformation curves for material which has been stressed beyond the elastic limit.

This test on a floor slab $3\frac{1}{2}$ ft. thick, 80 ft. wide and about 325 ft. long under an aggregate load of about 13 000 tons is perhaps the largest scale test ever made on a reinforced concrete structure.

Lock Gates.

The gates generally employed on lock construction are of two kinds, two leaf mitering and single leaf rolling.

Gates of the mitering type are usually of the design known as horizontally framed gates as contrasted with vertically framed gates. The gates for the Government Lock No. I will be of the latter kind but of radically new design. Without going into detail, I might point out the features of this design which are unique.

Each leaf of these gates is nearly 50 ft. square — about two thirds the size of the gates at Panama — and is divided into three panels by a lower arm, an upper arm, two intermediate posts, a quoin post and a miter post. The upper arms of the two leaves form an arch across the lock chamber and are so designed as to be in compression throughout. The four posts of each leaf are supported at the top by this arch and at the bottom by the heavy miter sill. The sheathing or " skin " is placed centrally rather than on either upstream or downstream, or on both faces of the gate. The rivets, consequently, are not in tension, and the upward pressure under the lower arm is reduced about one half, — the remaining pressure practically counterbalancing the weight of the gate. The sheathing carries its load to I-beam stringers, which in turn carry their loads to the posts above mentioned. As a result of this design the stresses in the gate are definite and simple, i. e., there is no combination of direct compression and cross-bending, and no uncertain distribution of load. In consequence, higher unit stresses are used, especially for the stringers and posts. The stringers are also varied in size and in spacing so that it becomes possible to more nearly develop the full stresses in all of the metal employed.

By eliminating most of the bending, milling, coping, etc., required in gates of the horizontally framed type the cost of fabrication in the shop was greatly reduced. The contract price for the structural steel (about 550 000 lb.) and for the castings and forgings (about 25 000 lb.) required for this gate averages only $2\frac{1}{2}$ cents a pound f.o.b. Pittsburgh. The simplicity of the framing and the accessibility of the rivets assures ease in field erection.

Concrete Pressure on Forms.

Although on much of the concrete work done at the present time the rate of filling the form in feet of depth per hour is comparatively slow, yet the occasional failure of forms and the

bulging apparent on much concrete work emphasize the necessity of more adequate form construction. A discussion of this subject, then, may not be amiss.

The only published tests of the pressure of concrete on forms aside from those made at the Government Lock in 1908, and published in an article by Major Shunk in *Professional Memoirs*, Engineer Bureau United States Army, July–September, 1909, pages 247–260, an abstract of which appeared in *Engineering News*, September 9, 1909, which have come to my notice, are those made by Mr. Ernest McCullough about 1894 and those made by Mr. L. E. Ashley and published in *Engineering News*, June 30, 1910. Some correspondence and editorial comment on these tests appeared in *Engineering News*, July 28, 1910. Tables giving the spacing of wire and bolts for walls up to 25 ft. high, based on Mr. McCullough's tests, were published by him in *The Cement Era*. They also appear on page 101 of his "Reinforced Concrete, A Manual of Practice," published early in 1908. Those specially interested are referred to the references given for the original published data relative to concrete pressure on forms. At this time, however, I wish to make some comments on the conclusions arrived at by the various investigators, and to present some new curves for guidance in form design.

Mr. McCullough's tables are based on the assumption that the pressure of wet concrete on the form is equivalent to the pressure of a liquid weighing 80 lb. per cu. ft., and that it increases directly as the depth, at least up to 25 ft. That is as far as his tables extend. He in nowise indicates that differences in temperature or variation in rates of filling have any effect on the pressure which the concrete will exert on the form. Yet his experiments were limited to temperatures around 100 degrees and rates of filling of 1 to 4 ft. per hour. About thirty measurements were made of the head of concrete in a bin 1 ft. 6 in. by 5 ft. required to break an inch board 8 in. wide and 5 ft. long bolted at the ends, closing an opening in the side of the bin. The unit pressure of the concrete was computed from the resisting moment of these boards as determined from actual tests on similar boards.

The deflection of the boards used in Mr. McCullough's tests, previous to rupture, must unquestionably have increased the arch action of the stone above the opening, and by yielding, these boards must have been relieved of a portion of the pressure. To what extent these factors influenced the results obtained it is impossible to say, but to show that they do influence the

pressure exerted by the concrete I would cite two observations:

(1) While building the lock walls of Lock No. I in monoliths 8 ft. by 18 ft. at the base, decreasing to 8 ft. by 6 ft. at the top and 25 ft. 9 in. high, it happened several times that rods tying the forms together broke, but the concrete — not being a freely moving fluid — relieved slightly by the yielding of the form, was partially supported by internal arch action, and the form, though weaker than before the breaking of the rods, withstood the remaining pressure.

(2) On October 1, 1908, while filling between two alternate monoliths previously built, the isolated monolith was suddenly tipped over about $4\frac{1}{2}$ in. at the top. Had the concrete acted as a freely moving fluid, the monolith, having once started, would of course have been tipped completely over. The slight motion, however, together with the friction against the face of the overturning monolith, relieved the pressure sufficiently so that the monolith again reached a stage of stable equilibrium. It might be interesting to note that if this huge block, requiring about $1\frac{1}{4}$ million foot-pounds to overturn, had actually fallen, it would have struck another isolated monolith and an entire row would in all probability have toppled over like so many dominoes set on end.

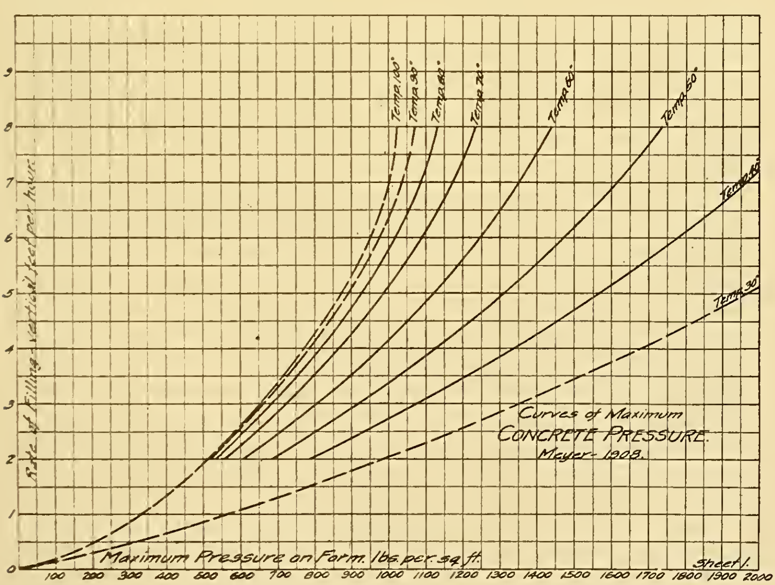

FIG. 2.

The facts above cited would indicate that concrete is never a freely moving fluid and that it does not exert fluid pressure for any great length of time at least. This is entirely in accordance with the facts shown in my tests, which, by the way, consist of over two hundred measurements. These measurements were made by means of a piston working in a short cylinder inserted into the side of a form. The apparatus is more fully described in the references before given. It was found in these tests made at the Government Lock in 1908 that the concrete exerted pressure equivalent to the pressure of a liquid weighing about 150 lb. per cu. ft. for a time dependent upon temperature, rate of filling and the depth of the layer which was continually being disturbed by puddling, spading, walking and the deposition of additional concrete in large batches. The time of deviation from fluid pressure, on the basis of a top layer of $2\frac{1}{2}$ ft. in depth being continually disturbed and thus kept from setting, was found to be given by the following formula:

$$T=C+\frac{150}{R}.$$

T=Time in minutes when concrete begins to show strength, setting and arch action combined.
R=Rate of filling in vertical feet per hour.
C=A constant varying with the temperature.

Values of C.	Temperature.
20	80
25	70
35	60
42	55
50	50
70	40

Assuming that the top layer which is being continually disturbed is limited to about 6 in. in depth, the above formula becomes $T=C+\frac{30}{R}$.

My 1908 curves (Fig. 2) giving the maximum pressure which concrete will exert against the form for various rates of filling and temperatures, are for use in designing forms for walls of heavy section, i. e., for mass construction. They are based on the assumption that a top layer of about $2\frac{1}{2}$ ft. of concrete is continually being disturbed, that the concrete is mixed *very* wet, that a rich, dense mixture is used, a slow setting cement, and that the concrete is being deposited in large batches and thoroughly puddled. The wet concrete actually used at the Govern-

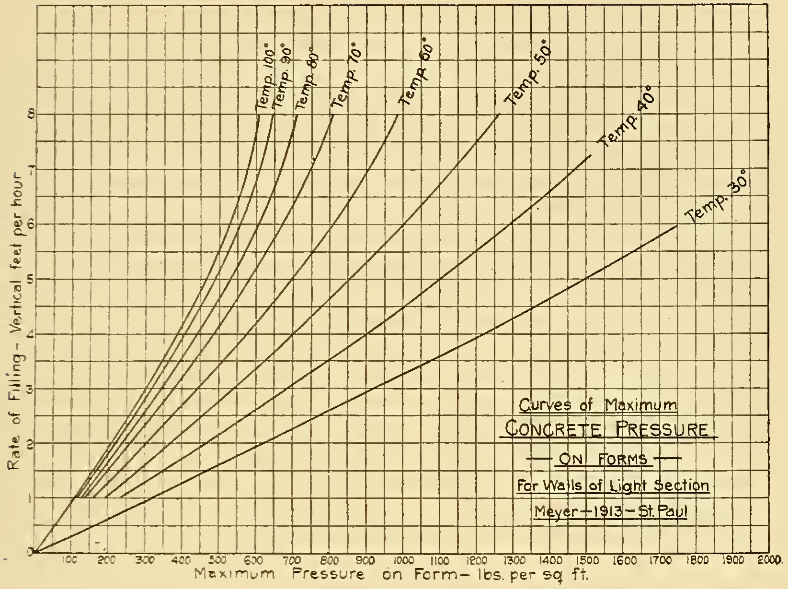

FIG. 3.

ment lock weighed, according to a number of tests, from 151 to 153 lb. per cu. ft.

From an additional study of the original experimental data I have drawn curves (Fig. 3) giving the maximum pressure of concrete on forms for walls of light section such as are commonly used in reinforced concrete construction.

The broken line curves giving maximum pressures under temperatures of 30 degrees, 90 degrees and 100 degrees (Fig. 2) have been added since these curves were first published by Colonel (then Major) Shunk and as they appear in Merriman's American Civil Engineer's Pocketbook, page 448.

In Fig. 6 are plotted the published records of concrete pressure on forms as given by Mr. Ashley's Gage No. 2 (reference previously given), together with his " Average " curve. There is also shown, drawn through the plotted points, what I consider a rational curve taking cognizance of the lunch interval. A marked similarity between this latter curve and one of my own curves, Fig. 4, is apparent. It will also be noted that Mr. Ashley's curve, instead of being headed toward the axis of " Head," is actually headed toward the axis of " Pressure." This is irrational and impossible, inasmuch as concrete, in setting, at least does not expand, but does continually gain in ability to maintain its shape without support from the form. The rapid

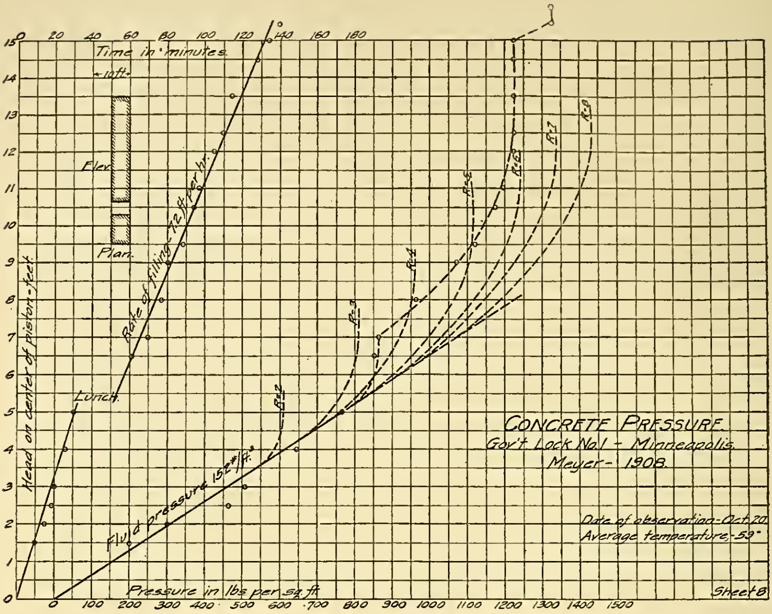
Time in minutes.
10 ft.
Elev.
Plan.
Head on center of piston-feet.
Rate of filling-7.2 ft per hr.
Lunch.
Fluid pressure 152#/ft.³
Pressure in lbs per sq. ft.
CONCRETE PRESSURE.
Gov't Lock No1 - Minneapolis.
Meyer- 1908.
Date of observation-Oct.20
Average temperature-53°
Sheet 8

Fig. 4.

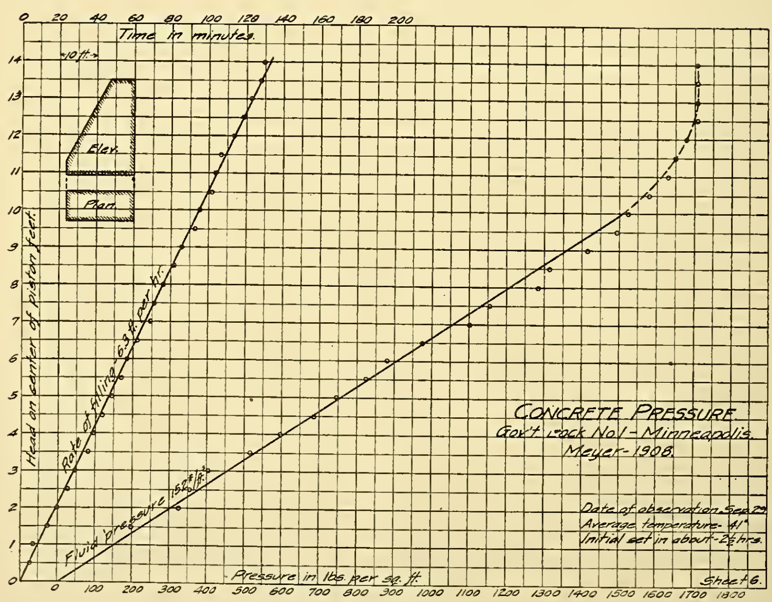
Time in minutes.
10 ft.
Elev.
Plan.
Head on center of piston feet.
Rate of filling-6.3 ft. per hr.
Fluid pressure 152#/ft.³
Pressure in lbs. per sq. ft.
CONCRETE PRESSURE.
Gov't Lock No1-Minneapolis.
Meyer-1908.
Date of observation-Sep.29
Average temperature-41°
Initial set in about-2½ hrs.
Sheet 6.

Fig. 5.

increase in pressure shown just before the close of Mr. Ashley's test merely indicates the manifestation of accumulated pressure which had previously not been exerted on the piston. The curve

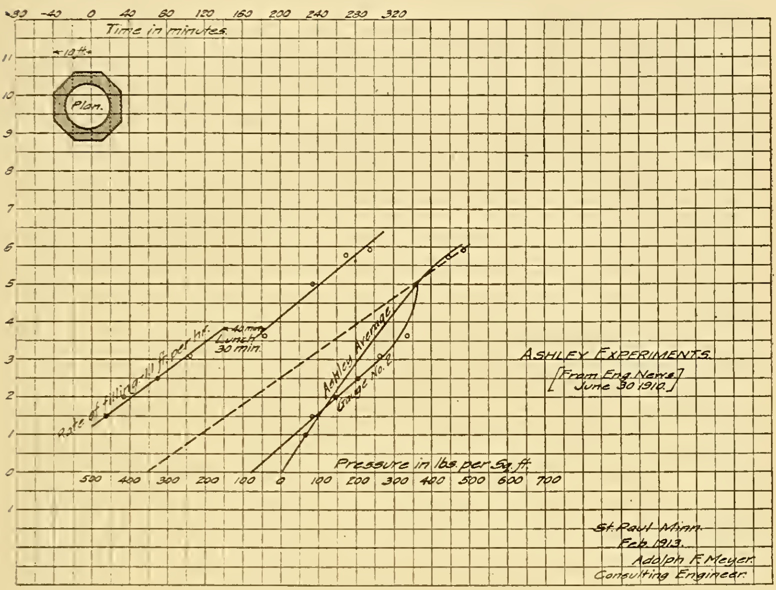

FIG. 6.

I have drawn through the lower four points indicates fluid pressure due to a liquid weighing about 120 lb. per cu. ft., and the broken line drawn through the upper three points indicates fluid pressure of about 140 lb. per cu. ft. Considering the fact that inasmuch as Mr. Ashley refers to "unequal tamping" as a probable cause for the variation (36 per cent. at 3.7 ft. head) shown in the pressures recorded by his two gages, it would be reasonable to assume that the concrete used in the Illinois experiments was not mixed as wet as that used on the Government lock. Moreover, a 1 : 4 : 4 mixture of such material as is customarily used in concrete work would contain considerable voids and consequently would exert less pressure because of its lower unit weight and diminished fluidity. In view of these considerations I hold that Mr. Ashley's tests bear out my own conclusions.

The editors of *Engineering News*, July 28, 1910, commenting upon these conclusions and on Mr. Ashley's tests say, "It is apparent that there are a number of discrepancies in the tests

made and reported by Mr. Ashley, but, in spite of these discrepancies, it will be noticed that the values derived by him are approximately the same as those reported by Mr. McCullough some years ago. With due regard to the tests reported by Major Shunk and defended by their maker, Mr. Meyer, we are inclined to believe that the pressure of a fluid of 80 lb. per cu. ft. is more nearly approximate to the true pressure of concrete than the remarkably high values obtained by Major Shunk, who found that the pressure for the first few hours (until the concrete had a marked set, in fact) was equal to that of a liquid weighing 152 lb. per cu. ft. This seems abnormally high and hardly in accordance with actual experience in form construction. — Ed."

I submit that such conclusions as those above given by the editors of the *News* can only be arrived at by a complete misinterpretation of the experimental data presented. Mr. McCullough's tables assumed fluid pressure up to a depth of 25 ft., corresponding to a lapse of over six hours in time, when concrete is being deposited at the rate of 4 ft. per hour. For this rate of filling at a temperature of 100 degrees my curves for mass construction give a maximum pressure of 775 lb. per sq. ft., corresponding to deviation from fluid pressure after $1\frac{1}{4}$ hours. According to my curves for walls of light section, deviation from fluid pressure under the above conditions occurs in less than forty minutes. Mr. Ashley's Gages 1 and 2 recorded rates of increase in unit pressure of 147 and 141 lb. per sq. ft., respectively, per foot increase in head, $4\frac{1}{2}$ hours after beginning to deposit concrete. For rates of filling and temperatures equivalent to those of the Ashley test my curves show deviation from fluid pressure after $3\frac{1}{2}$ hours and $2\frac{1}{6}$ hours respectively.

Given the temperature conditions under which concreting is to be done, and the rate in vertical feet per hour at which the concrete is to be deposited, my curves give the maximum pressure for which the forms should be designed. From zero at the top of the form the unit pressure should be taken as increasing at the rate of about 150 lb. per ft. until the depth corresponding to the maximum pressure is reached. Below this point the form should be designed for the maximum value given by the curve. For example, assume a rate of filling of 3 ft. per hour at a temperature of 60 degrees fahr. in a form for a reinforced concrete wall 15 ft. high. The maximum pressure to be expected under these conditions as given by the curve for walls of light section is 440 lb. per sq. ft. The form, then, should be designed for a pressure increasing from zero at the top to 440 lb. per sq. ft.

at a distance of about 3 ft. from the top and for a pressure of 440 lb. per sq. ft. from this point to the bottom of the form. The pressure diagrams corresponding to my own and that corresponding to Mr. McCullough's conclusions relative to concrete pressure on forms are shown in Fig. 7 for purposes of comparison.

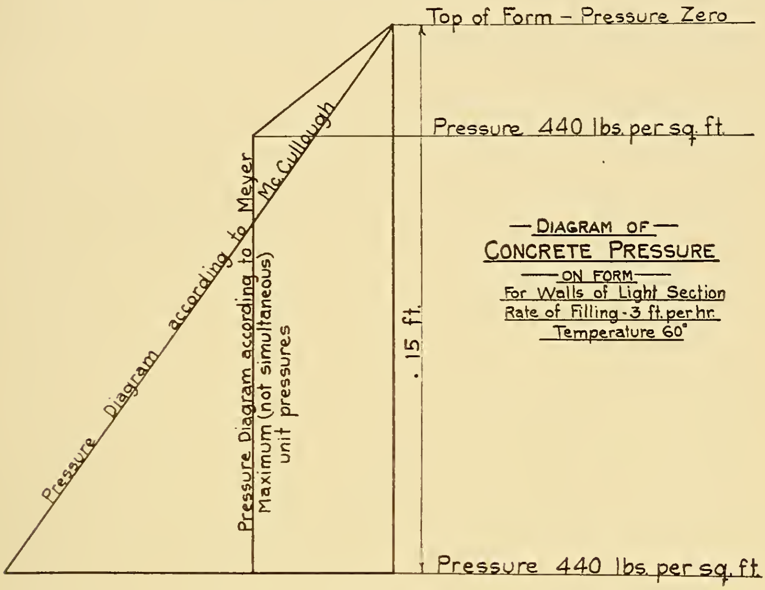

FIG. 7.

THE GOVERNMENT DAM AS A POWER SITE.

Available Head. — For the purpose of power development, the site of Government Dam No. I possesses two disadvantages, — great variation in head and in discharge. Partly counterbalancing the latter, however, is considerable pondage above the dam.

Fig. 8 shows the elevation of the headwater, the elevation of the tailwater and the head available for power development at various rates of discharge. The " headwater " curve gives elevations one foot below the maximum permissible elevation, as computed, to which the water above the dam can be raised at various rates of discharge without producing backwater at the lower power dam in Minneapolis. The crest of the dam as it is being constructed will be at elevation 743.5 ft. Cairo datum. Assuming 3 ft. of flashboards on the dam and a turbine installation capable of utilizing 5 000 cu. ft. per sec., the " headwater " curve will be modified as shown.

The "tailwater" curve gives the mean computed elevation of the water surface below the dam corresponding to various rates of discharge, after the dredging necessary to secure a 6-ft. channel at low water has been performed and on the assumption of similar stages in the Mississippi and the Minnesota rivers. Occasionally the Minnesota River, which enters the Mississippi River about 3.7 miles below the Government dam, produces as much as 3 ft. of backwater at the dam-site.

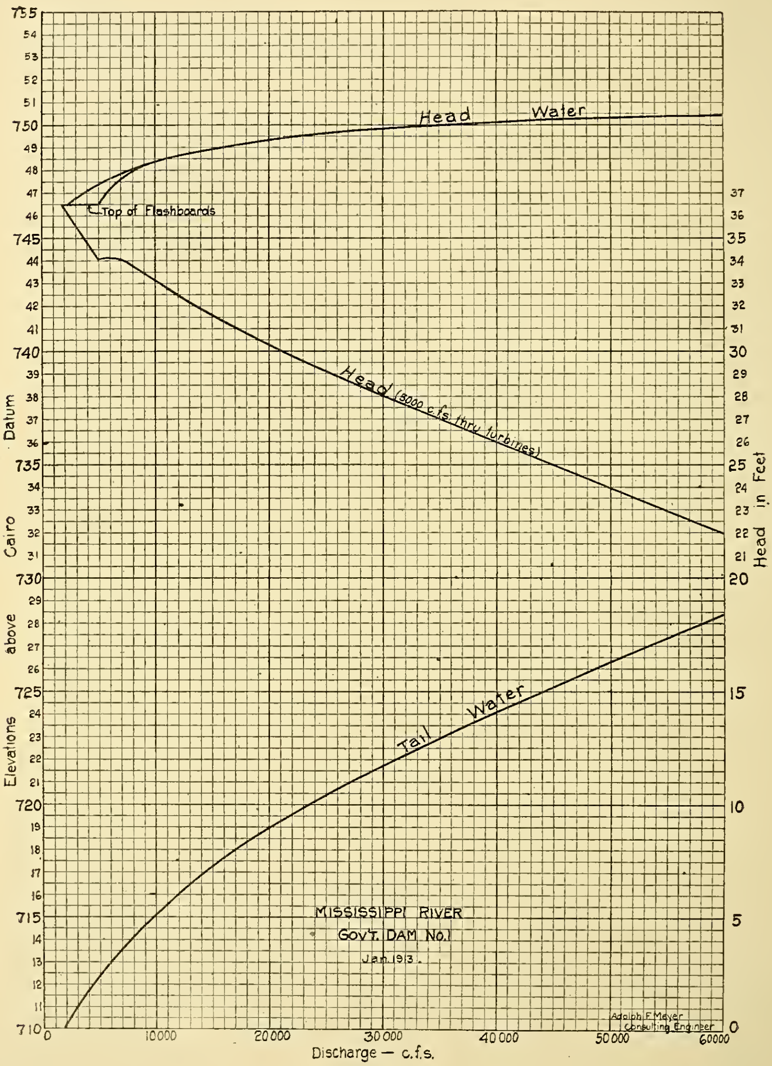

FIG. 8.

The curve of "head" gives the entire available head under the conditions above indicated. This varies from 36.3 ft. for a low water flow of 2 000 cu. ft. per sec. to 22 ft. during extreme flood conditions.

Available Flow and Power. — The eight yearly diagrams, Fig. 9–16, show the discharge of the Mississippi River at the site of the Government dam, together with the resulting power in kilowatts, assuming that the efficiency of the installation varies from 75 per cent. for all rates of discharge less than 10 000 cu. ft. per sec. to 70 per cent. for a flood flow of 50 000 cu. ft. per sec. The "run-off," "power" and "rainfall" curves shown may be called "frequency curves." The "run-off" curves give the number of days during each year beginning March 1 of the given year and ending the following February 28 or 29, during which the stream flow, as determined from records of the United States Engineer Office at St. Paul, was a certain number of cubic feet per second and the "power" curves give the power in kilowatts resulting from this flow and the corresponding head developed at the efficiencies before mentioned, assuming that a maximum flow of 5 000 cu. ft. per sec. can be utilized. The "rainfall" curves give the number of months during each year, beginning the preceding November 1 and ending October 31 of the given year, during which the average monthly precipitation at ten Weather Bureau stations distributed over the watershed of the Mississippi River above the Government dam, amounted to a given number of inches. The object in view was to show the relation between rates of rainfall and rates of run-off or stream flow. The rainfall year was taken as extending from November 1 to October 31 because the precipitation during the winter months on the watershed of the Mississippi River above Minneapolis practically all occurs as snowfall and does not appear as run-off until the following March or April. For the same reason the run-off year was taken as extending from March 1 to February 28 or 29. Stream flow at the Government dam site, during the winter months, is dependent almost entirely upon the rainfall of the preceding year. An advantage incident to this division of time is the fact that the low winter run-off is not divided between two years.

An examination of the curves of "power" reveals the fact that for a given installation developing 10 900 kw., this amount of electrical energy would be available for from only one to four months of each year. The maximum amount of power available for 362 days of each year for the years 1905 to 1912 is a

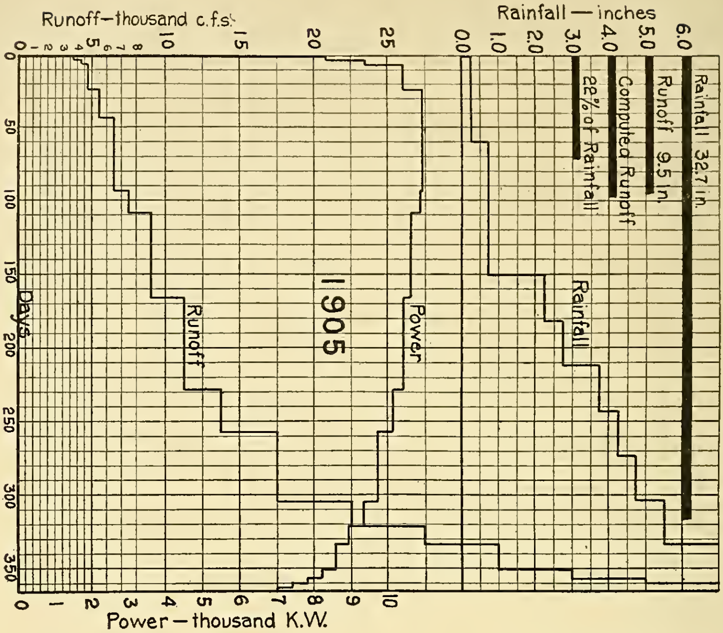
Runoff—thousand c.f.s.
Rainfall — inches
Rainfall 32.7 in.
Runoff 9.5 in.
Computed Runoff
22% of Rainfall
1905
Power
Runoff
Rainfall
Days
Power—thousand K.W.

FIG. 9.

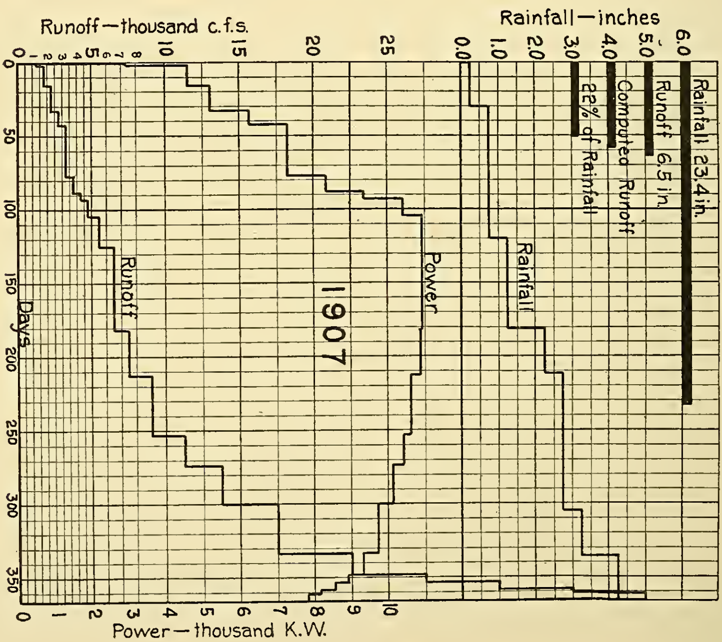
Runoff—thousand c.f.s.
Rainfall—inches
Rainfall 23.4 in.
Runoff 6.5 in.
Computed Runoff
22% of Rainfall
1907
Power
Runoff
Rainfall
Days
Power—thousand K.W.

FIG. 11.

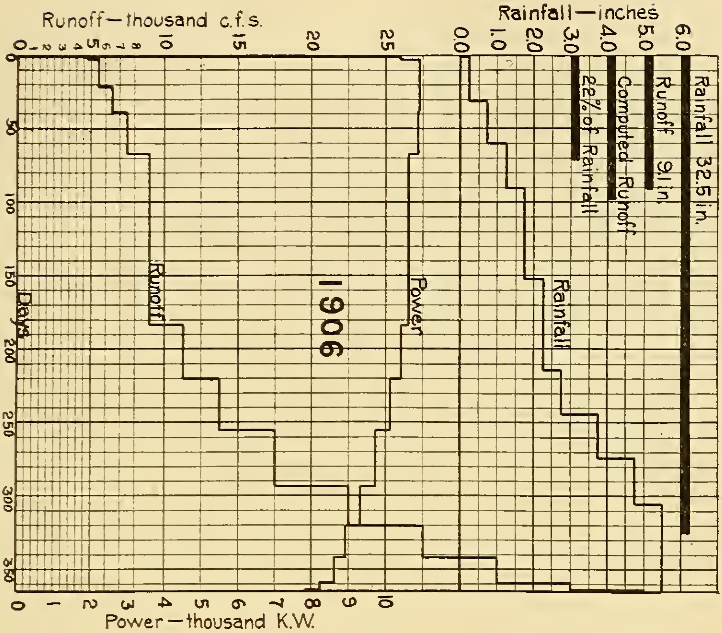
Runoff—thousand c.f.s.
Rainfall—inches
Rainfall 32.5 in.
Runoff 9.1 in.
Computed Runoff
22% of Rainfall
1906
Power
Runoff
Rainfall
Days
Power—thousand K.W.

Fig. 10.

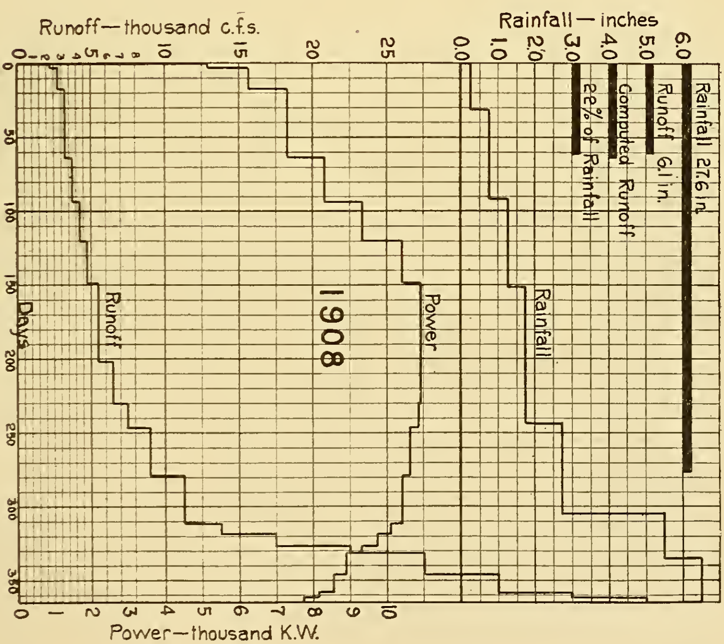
Runoff—thousand c.f.s.
Rainfall—inches
Rainfall 27.6 in.
Runoff 6.1 in.
Computed Runoff
22% of Rainfall
1908
Power
Runoff
Rainfall
Days
Power—thousand K.W.

Fig. 12.

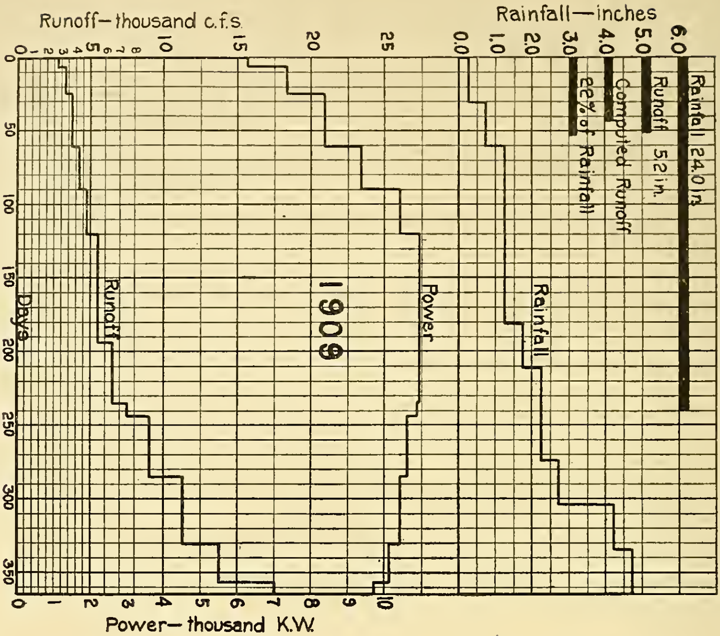
Rainfall—inches
Runoff—thousand c.f.s.
Rainfall 24.0 in.
Runoff 5.2 in.
Computed Runoff
22% of Rainfall
1909
Rainfall
Power
Runoff
Days
Power—thousand K.W.

Fig. 13.

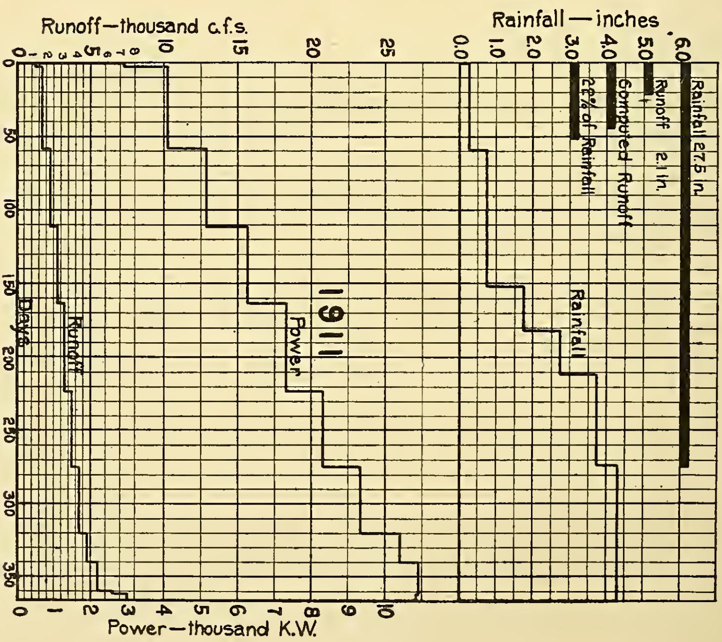
Rainfall—inches
Runoff—thousand c.f.s.
Rainfall 27.5 in.
Runoff 2.1 in.
Computed Runoff
22% of Rainfall
1911
Rainfall
Power
Runoff
Days
Power—thousand K.W.

Fig. 15.

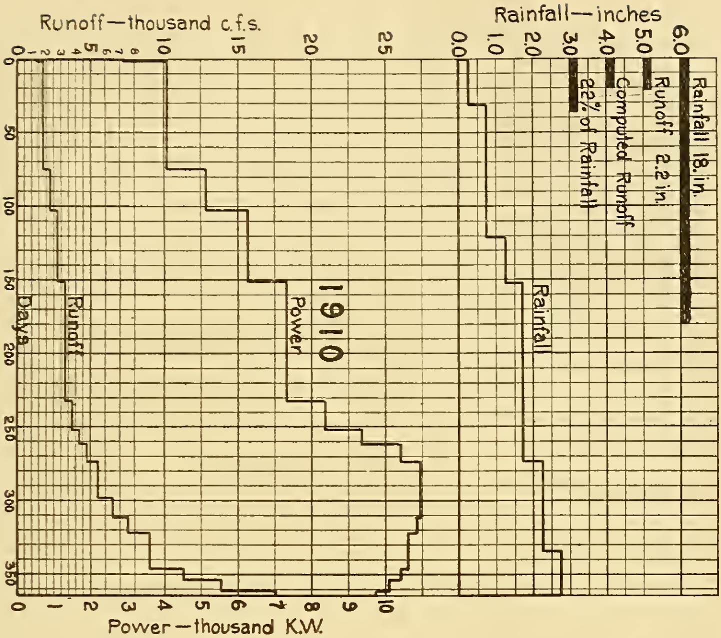
Runoff—thousand c.f.s.
Rainfall—inches
Rainfall 18. in.
Runoff 2.2 in.
Computed Runoff
22% of Rainfall
1910
Power
Rainfall
Runoff
Days
Power—thousand K.W.

FIG. 14.

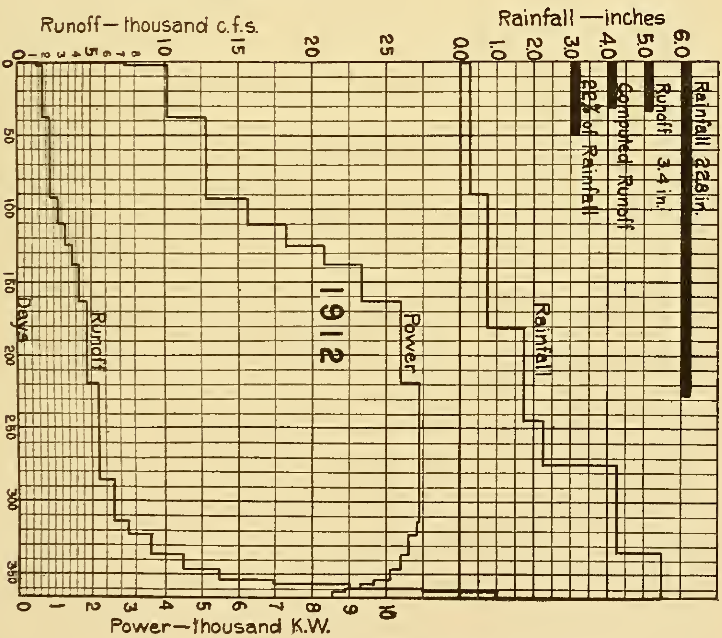
Runoff—thousand c.f.s.
Rainfall—inches
Rainfall 22.8 in.
Runoff 3.4 in.
Computed Runoff
22% of Rainfall
1912
Power
Rainfall
Runoff
Days
Power—thousand K.W.

FIG. 16.

little over 4 000 kw. The minimum monthly mean discharge during the navigation season, while the Government was discharging water from the reservoirs at the headwaters of the Mississippi River in an effort to maintain the river at St. Paul at a navigable stage, during the years 1905 to 1912, was about 3 250 cu. ft. per sec., corresponding to 7 300 kw. of electrical energy. This low rate of discharge extended over a total of about six months during the portions of the years 1905 to 1912 between April 1 and November 1, and resulted in river stages extremely unfavorable for navigation purposes, hence it is only reasonable to assume that no control of the flow will be allowed in the future when the rate of discharge reaches 3 250 cu. ft. per sec.; that is, the power plant will in all probability be required to pass at least the low water flow of 3 250 cu. ft. per sec. at all times during the navigation season.

During the winter months, after extremely cold weather, the flow occasionally falls to less than 1 500 cu. ft. per sec., but as this extreme condition is of short duration, the deficiency in flow can be largely supplied by drawing on the pondage above the dam. Inasmuch as no public or private interests below the dam would appear to be damaged by a control of the flow during the winter months, it would be possible to increase the winter flow of 1 750 cu. ft. per sec., which may be expected to continue for about two months and to occur twice every ten or fifteen years, to the minimum summer flow of 3 250 cu. ft. per sec., for six or eight hours each day by drawing down the pool. A minimum of 7 300 kw., then, would be available for twenty-four hours of each day during seven months of the year, and the same amount would be available for eight hours or more during the remaining five months. The absolute minimum would be 2 250 kw. for sixteen hours or less during these same five months when all flow in excess of 1 000 cu. ft. per sec. was being stored in the pond above the dam for the purpose of augmenting the natural flow to 3 250 cu. ft. per sec. during the eight hours or more during which the output was to be held at 7 300 kw.

In addition to the "frequency curves" shown on the accompanying sheet, the mean total rainfall in inches for the ten stations on the watershed is given for each rainfall year, together with the total run-off in inches from this watershed of approximately 20 000 sq. miles, during the run-off year. The run-off, however, represents the natural flow, the quantities stored or taken out of storage in the reservoirs at the headwaters having been added or substracted, respectively, from the recorded stream

flow at the dam site. For example, during the run-off year 1910 about 900 cu. ft. per sec. came out of storage, whereas during the run-off years 1905 and 1909 about 400 cu. ft. per sec. was added to storage in the reservoirs. The mean run-off for the eight-year period shown was equal to about 22 per cent. of the rainfall and to indicate how wide the variation of the actual annual run-off is from even this short period mean, a quantity equal to 22 per cent. of each year's rainfall has also been shown, together with the run-off computed from certain formulas which I have recently devised but which I will not now inflict upon you. These formulas take into consideration evaporation from land and water surfaces, temperature, requirements for plant growth, ground water supply, and other factors, and so far as they have been applied have given very satisfactory results.

Although the matters presented are in themselves quite unrelated even though they all relate to the same project, it is my hope that some one or other of the subjects treated may have been of interest to most of you.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the JOURNAL.]

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THADDEUS HYATT, AN EARLY AMERICAN INVESTIGATOR AND USER OF REINFORCED CONCRETE.

By Prof. Charles M. Spofford, Member Boston Society of Civil Engineers.

[Read before the Society, February 19, 1913.]

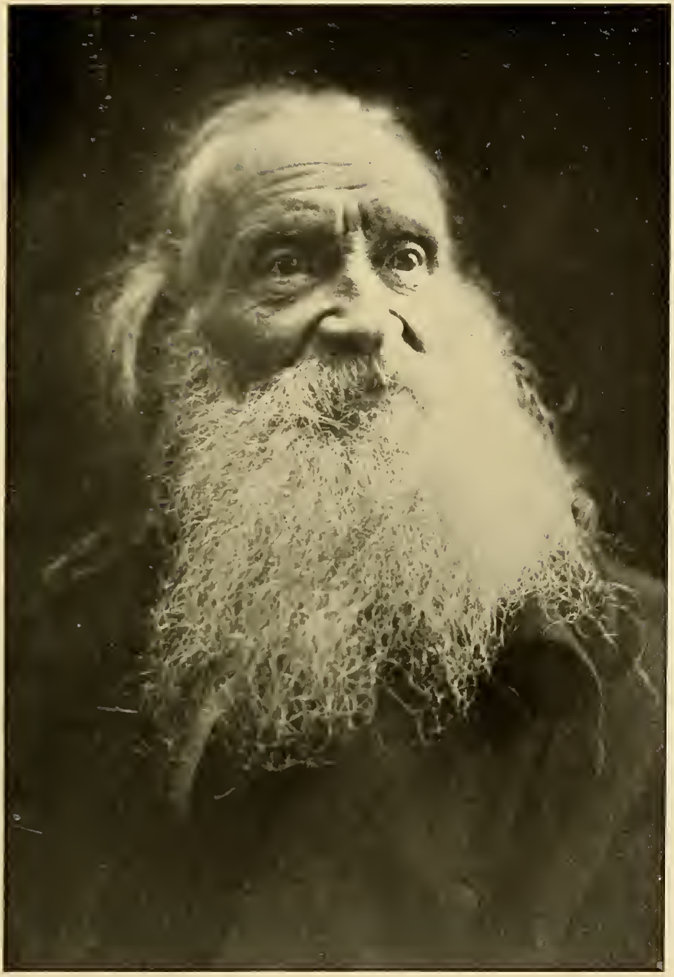
It is the purpose of this paper to give a brief description of an American, Mr. Thaddeus Hyatt, who was one of the earliest users of reinforced concrete, and who has not received as yet the credit to which the writer believes him entitled.

Mr. Hyatt was a lawyer by education but an inventor by nature. He was born in New Jersey in 1816, but lived most of his life in New York City and London. One of his early inventions was an illuminated sidewalk grating, the use of which first made it possible to light the basement areas under the sidewalks of New York City, thereby adding materially to property values. The Hyatt grating is still made. The manufacture of these gratings soon proved sufficiently profitable to enable Mr. Hyatt to leave the conduct of this business in the hands of his managers and devote his own time and considerable money to experiments and study along other lines. Among many subjects which had long interested him was fireproof construction, he having early recognized that the unprotected iron then employed in so-called fireproof buildings was by no means fireproof. His use of Portland cement in conjunction with iron in the manufacture of gratings convinced him of the value of a combination of these materials both with respect to strength and resistance to fire, and he was led to experiment very extensively with such a combination.

In 1877 he published privately a book giving his views upon fireproof construction, together with results of tests of various combinations of iron and concrete. The title of this book is "An Account of Some Experiments with Portland Cement Concrete Combined with Iron as a Building Material with Reference to Economy in Construction and for Security against Fire in the Making of Roofs, Floors and Walking Surfaces."

Among the subjects which he investigated were the following:

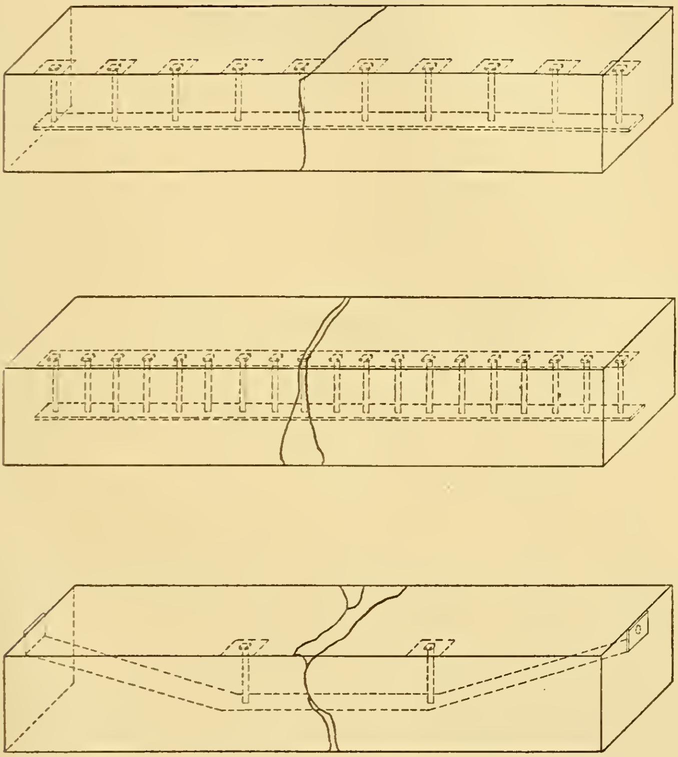
The fireproof qualities of floors made of Portland cement and iron. The heat conduction power of concrete. The coefficient of elasticity of concrete. The strength of concrete beams with iron rods and bars embedded therein. The effect of quench-



Thaddeus Hyatt.

ing red hot concrete in cold water. The relative economy of solid floors of concrete with tension steel embedded therein as compared with floors composed of concrete and rolled beams.

The beam tests were made by Kirkaldy, the well-known testing engineer, and are very interesting. The figures accompanying this paper show some of many different combinations which he tested, and serve to indicate the wide scope of his experiments.



Specimens of Reinforced Concrete Beams Tested for Thaddeus Hyatt.

From the results of his studies and tests, Mr. Hyatt drew the following conclusions:

a. That fireproof construction requires that all iron beams shall be absolutely surrounded by fireproof material.

b. That Portland cement concrete is fireproof.

c. That the bond between concrete and iron bars or rods is sufficient to develop the strength of the iron, and that

such a combination is much more economical than one consisting of concrete and rolled beams.

d. That the coefficients of expansion of iron and concrete are practically identical.

e. That the ratio between the moduli of elasticity of concrete and wrought iron is about 1 to 20.

f. That high concrete chimneys reinforced with metal extending upward and threaded upon *wire hoops* should be lighter, cheaper and stronger than unprotected chimneys.

g. That concrete combined with tension iron may not only be used satisfactorily for buildings, but that this material should also be satisfactory for bridge construction, since such a bridge should be weather-proof, need no paint, and probably cost less for repairs.

Hyatt was so firmly convinced by these studies of the desirable qualities of reinforced concrete that he constructed a building on Farrington Road, London, in which he used much of this material. To convince others of its fireproof character, he built a fire in it without causing material damage. The building is still in use and has been visited by the writer.

A search through the records of the United States Patent Office shows that he was granted one patent of broad character covering the use of combinations of concrete and metal. This patent, No. 206112, was described as follows by the United States Patent Office Gazette of July 16, 1878.

"*Composition floors, roofs, pavements, etc.*

"*Brief.* — Hydraulic cements and concretes are combined with metal bars and rods so as to form slabs, beams and arches. The tensile strength of the metal only is utilized by the position in which it is placed in the slabs, beams, etc.

"*Claim.* — The manufacture, use and application of the aforesaid materials, and the modes, means and processes connected therewith when the same are employed for the purposes and in the manner substantially as hereinbefore set forth and illustrated by my drawings."

The following portion of the original claim made by Hyatt is of particular interest as indicating the origin of the modern deformed bar, and in showing his knowledge of the importance of the shearing stresses in a reinforced concrete beam.

To all whom it may concern:

"Be it known that I, Thaddeus Hyatt, of No. 25 Waverly Place, in the City of New York, a citizen of the United States, have invented certain new and useful improvements in the use and application of hydraulic cements and concretes in combina-

tion with metal as a building material and in building constructions made therefrom, and in means, modes and processes connected therewith, the same being in part applicable to pavements and other walking and load bearing surfaces and structures.

. . . .

"That iron or steel may be combined with concrete or with bricks as tie metal, capable of furnishing all tensile strength needed to balance the compressive resistance of the other materials when the beam or structure is subjected to bending stress, that all metal may be dispensed with save the tie only, and that both baked bricks and concrete possess in themselves cohesive power and strength sufficient to perform the functions ordinarily performed by the metallic web, are the discoveries made by me through many experiments and years of study, upon which I now base my application for a patent.

"In applying my invention to the construction of floors and other walking surfaces, and low-bearing structures, and to roofs, to the making of beams, joists, girders and supports, and to the making of pavement slabs not liable to crack from their own weight by the giving way of imperfect foundations underneath them, and to the construction of 'roof-pavements,' for extending the basements of buildings under the footways of public streets, my improvement consists in the use and application of iron or steel as tie metal, combined with the concrete or bricks, to give tensile power to the same; my invention, with respect to the tie metals, consisting in so preparing or making them as to prevent the possibility of any sliding or slipping of the materials one over the other when the beam or structure is under strain.

"For resisting thrust, as, for example, in the 'bow-string girder,' a tie may be made dependent upon the two end fastenings only; but a beam proper must be qualified to resist cross-strains, and equally well at any part. The tie must of necessity, therefore, be attached to the web practically throughout its entire length, and as firmly at one point as at another, the object of such fastenings not being to prevent the tie from bursting out or breaking away from the web in a downward direction, because no such tendency exists, but to counteract the tendency of the tie to slide or slip because of the force of the shearing strains got up in the beam when under bending-stress; this discovery of the true relation existing between a tie and its web also demonstrating the sufficiency of the cohesive power of the web itself to hold the tie to the top of the beam, whether such web be concrete or metal, the difference of thickness necessary for this purpose, where the web is concrete instead of being metal, being proportionate to the difference between the cohesive strength or power of metal and concrete. Basing my improvements in the ties and the manner of connecting them with the concrete upon the theory above set forth as to shearing strains, I find it important to make use of ties having the greatest friction surface. Flat thin ties are

hence preferable to other shapes. To prevent slipping, these ties require also a roughened surface. This roughened or non-slipping surface may be made in many ways. For some purposes a mere sanded tarred surface may possibly suffice; but I prefer to use *metal specially rolled for the purpose, with bosses or raised portions formed upon the flat faces of the metal.*

. . . .

"Non-slipping ties made substantially as herein described and illustrated, I propose to make and put upon the market as a new manufacture, and as a substitute for the metal in beam form."

This brief sketch would be incomplete were no mention to be made of Mr. Hyatt's notable activity in lines distinct from those we have described. During the years preceding the Civil War he was active upon the anti-slavery side, and spent time and money with great liberality to prevent the extension of slavery into Kansas. During the heated contest which arose over this question he was continually engaged in planning public meetings and in traveling back and forth between Kansas and New York. He himself made but few public speeches, but was content with the organization of these meetings and the defraying of the expenses. His interest in this subject brought him into intimate relationship with John Brown, and after the Harper's Ferry incident he was called before the United States Senate to testify. This he absolutely refused to do; consequently he was imprisoned for thirteen and one-half weeks in the Old Capitol Prison in Washington. Undisturbed by this, he made himself as comfortable as possible, invited his friends to visit him, and continued his campaign against the extension of slavery by the organization of more meetings and by vigorous newspaper articles. His imprisonment was not long continued, as the pro-slavery senators found it of little avail.

At a later date, soon after Lincoln's election, the famine in Kansas gave him another opportunity to show his public-spirited nature. The state was nearly exhausted, but through his personal efforts a relief committee was appointed, through whom a fund of $1 000 000 cash was raised, in addition to many other gifts, the proper distribution of which he directed personally, and so wisely that the state was soon in a prosperous condition again. His unselfish devotion to the welfare of the state was widely recognized, and it is related that a prominent lawyer, upon meeting him for the first time, exclaimed, "Mr. Hyatt, the people of Kansas should erect a statue of gold to your memory!"

His death occurred in 1901, at the age of eighty-five. More fortunate than many, he lived to see the widespread adoption of his system of fireproof construction, the complete extinction of slavery and the rise of Kansas to a high position among the other states in wealth and importance.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the JOURNAL.]

ANNUAL ADDRESS.

By D. C. Henny, President of the Oregon Society of Engineers.

[Read before the Society, February 13, 1913.]

The past year's work of our Society has been marked by a healthy activity in various directions in accord with the objects of the Society. Our monthly meetings have been interesting and well attended. A wide range of subjects has been covered by the papers read before the Society, these papers have received the desired publicity, and our financial affairs are in a satisfactory condition.

The Society has taken an active part in the consideration of pending legislation, from the high standpoint rather of the good of the public than to foster narrow professional interests, and above all a closer acquaintance has been cultivated between our members through meetings and social gatherings.

A new step which has been taken during the year and which has had the enthusiastic support of the membership is the organization of the Portland Technical Club. The Portland Architectural Club and our Society have joined hands in the maintenance of common quarters where we can feel at home at our meetings, and it is hoped that this feature can be developed so as to be of daily increasing use to our members.

Aside from fostering acquaintance among ourselves for professional development, there are undeniable advantages in the professional man's keeping in close touch with the broader topics of the day. This is perhaps more true of engineers than of men of other professions.

At college, educational requirements are sufficiently severe to leave little time for study of subjects outside the selected engineering course. The desire for a broad and so-called classical education is satisfied with one or two years' study of a dead or even a live language, which is far too superficial to be of any practical use, while there is no effort of any kind to awaken genuine interest in art and literature.

In these respects there is perhaps not much difference between students of law or medicine and of engineering up to the time of graduation. The education for all is specialized so as to be bound by rather narrow limits, and subsequent contact with the world is, and perhaps must be, depended upon for healthy

and broadening influences. This expectation is not always immediately realized in the case of the engineer. Young doctors and lawyers come in direct contact through their professional work with men of all classes and constantly see phases of life which develop broad tendencies. The engineer of the same age is most likely to work under the direct supervision of older men of his own profession, upon whose judgment his reputation and progress largely depend. This fact, while favorable to technical development, has a narrowing tendency and keeps a large number of young engineers out of direct touch with the general public.

The engineer's work, moreover, often takes him for long periods far from centers of civilization, which is physically beneficial but intensifies the practical seclusion in which many pass their early years. During that time habits are contracted which it is hard in later life to overcome under more favorable conditions.

It is perhaps not surprising, therefore, that the number of engineers found in political life, for instance, other than employees, is small considering the large number of graduate engineers. Oregon recently sent a physician to the United States Senate to replace a business man. His associate Senator is a lawyer, while engineers are not to be found in that august body. Nor are there any at the present time to my knowledge in the House of Representatives. The same is generally true as regards the state legislature and the city government. It must be admitted that in the case of a neighboring city the unusual sight is presented of an engineer in the mayor's chair, an exception which has been commented upon to an extent which goes far to prove the rule.

The engineer's usual absence from offices of public trust, other than in his professional character, can hardly be accidental and may be owing to the causes referred to, and while these cannot be readily removed, since they are partly inherent in the character of the engineer's early work, much can be done to counteract the effect.

Time taken from professional study to attend meetings where contact is obtained with all manner and conditions of men is not to be considered as wasted or lost, but rather as filling an urgent need, especially so far as the younger men in the profession are concerned.

It is for the above reasons that great value must be attached to any means by which the engineer may become directly inter-

ested in the important questions of the day, and this is attempted by an innovation inaugurated during the past year. A weekly luncheon has been arranged for, the special feature of which is an address on a topic of general interest by some prominent guest not usually connected with the profession. These gatherings are not only thoroughly enjoyable, but they take the mind completely out of its work-a-day grooves and open the eye to the larger scope of the work of the engineer as a citizen. These meetings have been remarkably successful and they represent one of the most valuable results due to the activity of our Society.

The labor of pushing ahead along these and other lines will hereafter devolve to some extent upon new shoulders. The term of office of some of my colleagues, as well as myself, is about to expire, and it affords me genuine pleasure to record the fact that thorough and unselfish coöperation has characterized the work of the directors and officers of our Society. It may be earnestly hoped that this spirit of team work may continue, to the end that our Society may satisfactorily fulfill its functions in being of real benefit to its members and performing its share towards the betterment of general conditions.

RATES AND RATE MAKING.

By John F. Druar, Member of the Civil Engineers' Society of St. Paul.

The subject of rates and rate making is one of such proportions that it will be impossible at this time to more than touch on some of the salient features of this engaging subject.

I say engaging advisedly, for at the present time I believe there is more agitation along these lines than ever before, not alone for the heat, light and power companies, but for other public service corporations, such as railroad and other public carriers, the tariff and various commodities of civilization.

In order to properly follow this subject it might be well first to call attention to rates as being one of the earliest subjects with which man was concerned. No matter what was purchased from the earliest times to the present day, there was always room for argument. The earliest peoples no doubt had a schedule of rates, and wherever man traded or bartered, rates were concerned, and rates of exchange have in the past caused first arguments, and then wars, even as at the present day disputes of this nature lead to the courts when the attempted adjustment of rates is not satisfactory to the parties concerned. There is not a man among you who has not asked the price or rate upon commodities of various classes and who has not thought that he should have a lower rate than that fixed perhaps arbitrarily by the parties interested in the sales or delivery of the goods in question. You on your part had a right to ask for closer prices or rates of transportation, due to the fact that you were using more material than your neighbors, or were shipping more goods by a certain road, or that you were traveling exclusively between certain points each day and, therefore, you had a right to expect some concession through your purchasing power, the magnitude of your business or for various reasons, which when you come right down to it can be called special privileges of your class, or of the class to which you for your own selfish motives think your ingenuity is entitled, whether it be for a commodity, a railroad freight rate or the cost of electricity or gas. With the latter commodity there are thousands of people who would not like to be classed as thieves who attempt to adjust their own grievances with an electric or gas company by beating the meters

installed on their premises. Strange to say, the statistics of the public service companies point to women as being in the majority of this class of offenders who try to delay or even stop the meters used for the sale of these commodities. Thus it will be seen that the people strive in one way or another either honestly or dishonestly to adjust for themselves the rates charged.

With the knowledge that this adjustment of rates has been a feature of life from the earliest times, it is indeed very queer that the subject has only recently been given grave thought, and only now have measures been adopted for the investigation and fixing of rates along all commercial lines.

The principles have not even to this time been given the great thought and study necessary to produce uniform results. We find that various boards, utilities commissions and other bodies, empowered to fix rates, attack these problems from different viewpoints and under different methods. The courts when asked to determine the justice of the established rates, or of proposed rates, do not do so with any degree of uniformity, nor does the decision of any court stand unless it happens to be to the liking of the public service corporation. For many of these decisions have been attacked and reversed or reëstablished.

The main reason for this is that there have been no fixed rules to the game. On the part of the majority of the companies producing light, heat and power, there has been no attempt to keep down initial expense. Rather, there has been that intense selfish desire to produce wealth other than by the economical production of power, for which the companies were first created. If these companies could be once created, then financed, re-financed, traded and expanded, built and rebuilt, then the original investment adequate at the start would be so manipulated as to produce a large amount of wealth for the original promoters, all without any real or legitimate outlay on their part. In fact, there are a number of such producing companies which have been turned over to the public, misrepresented and sold to them, that by reason of these burdens can never be expected to produce electrical energy or a supply of gas at anywhere near a fair and reasonable rate to the consumer.

Is it any wonder that with these conditions existing there is trouble and turmoil? The greatest wonder is that there has not been a revolution and an adjustment of these questions attempted before now. The only reason appears to be that the old saying that everybody's business is nobody's business holds true.

The main question to be answered, then, appears to be, What will be the method of procedure to regulate the rates of a public utility corporation? Now upon this method depends, of course, the amount of investment charge that has to be taken care of, and having determined the investment, it is then necessary to fix or assume a rate of interest and depreciation, and thus affix an earning value to the utility. Having done this by whatever method we adopt, the next point we have to deal with is the adjustment of the rates of the various classes of consumers to create the revenue to secure the income. Now as the nature of the loads or demands on a plant is constantly shifting between certain limits, it is very hard to arrive at any fixed method of the determination of rates. In fact, it can be said that the rate charges cannot wholly be figured out on any scientific basis. There is no formula that will apply to the distinctive classes of business.

I will now take up the question of the valuation of a combined electrical and gas property for the purpose of determining the legitimate capital to be figured, upon which capital a certain return should be received by the investor.

The various state commissions and courts have not aimed at any one method of determining this amount or value, and in many instances their findings differ widely.

Some commissions have used a continuous property theory, which theory involves taking the investment from the conception of the first company of the now complete corporation (comprising perhaps four or five or as many more different small companies), and figuring the additional investment of each succeeding year, adding the purchase price of each succeeding company that was joined to the original company. Each of these amounts is supposed to be added to the investment yearly. It is now assumed that the stockholders have been assuming a larger risk and are entitled to a larger return on their money than an investor in bonds. Therefore they consider 8 per cent. as a reasonable return for the type of investment. Then, if upon the purchase of the first plant the company is able to put by a sinking fund of 5 per cent. and earn 8 per cent. on the investment, the investment stands the same for the second year, but if as highly probable at the outset the company does not pay the 8 per cent., but pays only 2 per cent., then that amount equal to the deficiency is capitalized and added to the capital invested and the next year earnings must show 8 per cent. on the increased capitalization. If, however, the company should be

ridiculous enough to earn more than the 8 per cent. allowed, then the amount is deducted from the investment and it is reduced to that extent.

This scheme is manifestly unfair, for there is very often no chance of going back from fifteen to twenty years to determine whether the old books or reports are true or whether the sale price included good will or what not.

Another method used is to arrive at the investment by determining the cost of reproduction of the plant new, and with this established value to figure the rate of return on the investment, and to adjust the rates from this standpoint. This method is apparently the one most in use at the present time, but it is my belief that this method is not carried far enough, for while the company will insist on having amounts added for a large number of items, and in many instances very heavy ones, in some cases totaling a fairly large percentage of the whole, it likewise will combat any effort to place a cost price on the construction, although it will insist on such items as are contained in the following list: exploitation charges, cost of organization, legal advice, costs of incorporation, underwriting of bonds and stock (very often sold below par), engineering fees, contractors' profits, permits, insurance, interest on construction, interest on working capital, and a number of these percentages which should or should not have entered into the cost, due to the possibility of having been charged in under the various items.

It appears to my mind to be far more reasonable to abandon the past to its fate and to work up a strict evaluation of the cost of the reproduction of the present properties through first making a complete inventory of the entire properties as they appeared at a certain date, to affix the reproduction cost by allowing the company to present the actual signed contracts for the work where possible, and to acquire the necessary data from all sources as to those costs which cannot be established in this way, after having given the company the opportunity to check over the inventory. In making up the inventory it is evident that a carefully outlined scheme of procedure should be adopted from the start so that each item may be checked separately and be at once segregated from the whole. I shall outline the following as classifications which will allow of some variations. Where valuation sheets are made in any of the following work they should be carefully worked out so as to contain every point of information which may be needed in the work. Ample space should be left for the company's valuation, if a valuation has

been made by the company, space for at least two prices, such as estimated, and contract price, location of equipment, year of installation, name and description of units of machinery, weights, freights, remarks and space for the appraiser's signature who has compiled the information. These blanks should be of convenient size for handling, and should be so designed as to be readily placed in a binding without covering any of the data contained therein. Each sheet should be accompanied with letters, sketches, etc., pertaining to the special apparatus, and with copies of contracts of installation, the size and nature of foundations, etc., the purposes of use; spaces for depreciation of various kinds, whether caused through any of the classes which will be treated later. We now come to the special heads.

Real Estate.

This should be accompanied with neat sketches of location of the various properties, with the location of streets, railroad sidings, street cars, dockage, sewers, water, etc.

Description should be had of the influence on the valuation for other purposes than those for which it is used. The purchase price should be determined if possible, the assessed value and appraised value by disinterested parties. The assessed value of surrounding property and other important information should be shown. Space for the depreciated or appreciated value percentages, etc., should be arranged for, together with remarks as to the necessity or adequacy of the property for the purpose used, etc.; if used for both electricity and gas, the relative value should be assigned to each.

Buildings.

Buildings should be carefully listed as to uses and proportional uses, whether for electricity or gas. Proportional charges against the different amounts of space used for various operations or classes of service should be made. Plans of buildings should be obtained and carefully checked to see that depths of foundations and all other data check. Any difficulties of construction should be carefully listed, as well as any peculiar circumstances pertaining to construction costs, such as delivery of material, etc. Careful lists of material and quantities entering into the construction of the buildings should be made in detail and checked. Columns should be left for estimates and prices, and all should be arranged for separate sheets for totals.

Settlement of foundations and other data should be noted, and, in fact, any notes should be made which might influence the depreciated cost for other than the wear and tear of age. Date of start and completion of erection should be entered.

Station Equipment.

Here extreme care must be employed. Data sheets must be carefully worked out to contain make of equipment, size, capacity, class, types, forms, date of building, date of purchase, date of erection, etc., the size and depth of foundations, weight of equipment, use to which equipment is put, special notes as to accidents, fires or other trouble engine or other apparatus might have encountered. Space must be left for various percentages of depreciation due to wear and tear, inadequacy or obsolescence and for other remarks. The card should be so arranged that all the work and equipment may be listed which is connected in the peculiar chain of apparatus. Of course the nature of each piece of apparatus must be carefully defined, and all information as to its respective use tabulated, whether for the gas or electric department, or if used partly for one and partly for the other.

Overhead Construction.

Working maps should be made of convenient scale, one tracing for electricity and one for gas.

First the map is made and blue prints obtained devoid of any information. The city is then divided into sections and crews of two assigned to a section. They take the blue prints or convenient sections of same and make a thorough survey of all poles, their location, condition, etc., even as far as to securing information of the placing of foreign wires thereon. They carefully check the wires, cross arms, lamps, transformers, switches, junction, number of leads to consumers, etc. The same detailed information is secured for the gas except that at points it will be necessary to dig up the mains and test same for condition, size, etc. Recourse in some instances may be had to the maps and data of the public service corporations, and these data can then be compiled in the office and later checked for location and condition.

Underground Construction.

Maps are made of the underground construction as above and special construction requires special sketches. All cables, all wires with connections to consumers, are carefully listed and

measured. The manholes are measured for nature of bottom and size, connections to sewer, etc., all plotted and arranged to give all the required information.

Now, with the above information carefully tabulated and arranged, together with contract prices where possible, costs taken through a period of four or five years before the appraisal, averaged carefully to arrive at cost of material, applying the same method to labor and other data required and securing actual estimates and figures of work installed from contractors, then, from the tabulation and compilation above, the physical value of the plant is arrived at.

Intangible Values.

Now, in addition to the physical or tangible value of the plant, the company is or should be entitled to receive a return on any special costs of organization, the securing of a franchise, interest during construction, contractor's profit, engineering, insurance and taxes during the construction, discount on bonds and on sale of stock, etc. These additions are variously given by different engineers, lawyers and courts, and vary all the way from a minimum allowance of 11 per cent. to a maximum of 43 per cent. of the total cost of the plant. I believe it then becomes necessary to make deductions from the value of the entire plant as obtained above and to allow the earnings only on the depreciated value of the plant. It might be said, this is for the reason that I feel that the mere granting of a franchise to an operating company makes it obligatory on its part to strive to keep the cost of current or gas at a reasonable rate and not to strive to inflate values until the commodities and the cost of service reach ridiculous bounds. I feel that the company cannot place a value on its franchise or good will on which it should be permitted to earn money, as has evidently been done in more than one case where small concerns have sold out to larger corporations and the good will and franchies sometimes have been practically the only assets of the lessor companies. Thus the people are often required to pay interest on a fictitious value for something they gave away or really control.

I shall now take up the deductions to be made under the following heads.

Wear and Tear.

This means the wearing out of the equipment in service. At first it would seem that this would be the principal charge against the depreciation of the plant, but such is not the case.

There is a very small amount of equipment that in reality is discarded for this reason, and this is not as important an item as it might seem.

Obsolescence.

Obsolescence is the cause of discarding equipment owing to advance in the art. This charge is relatively high in comparison with the wear and tear, but has fallen off some in the last few years because the machinery has reached a definite stage or type and is not replaced with new types as frequently as before. Machines have now reached a stage of good efficiency and while some increase in efficiency could be obtained it would no longer be a marked saving to eliminate electrical apparatus for new equipment.

Inadequacy.

Here there is a large percentage of loss, for almost all equipment is removed for this cause, which may be described as being outgrown by reason of new demands on the equipment, and it would not be policy to keep a large number of small units with the attendant losses in each when one large unit would not require half the space and the losses would be much reduced through the use of one unit. Thus we see perfectly good equipment displaced for these reasons.

After suitable deductions have been made from the cost of reproduction to take care of the above items of depreciation and the further depreciation of all equipment, then we arrive at the actual amount on which there should be allowed an adequate return.

I now come to the fixing of the rates, and herein lies a monumental task, for rates vary: the fixing of them varies still more.

There is probably not one among you who will not recognize the fact that there should be a difference in rates to various classes of consumers, and I will say that I am thoroughly convinced of this. I again repeat that there is no exact science to rate making either for gas or for electricity. No formula can be followed, and while we may make determinations for a space, we come to a place where mathematical deductions will not carry us with any justice to all classes of consumers. There is a point where the rate given a big consumers becomes a burden on the balance of the consumers, and when this point is reached it is well to raise the rate and take a chance at the loss of the business, for it would be manifestly unfair to the smaller consumers to maintain several of these consumers at the expense of all the smaller consumers. This, however, has been done in a number

of instances because of rivalry between two competing companies for the large consumer.

When after having obtained the above-outlined data we come to the point where we desire to fix the rates, we see that it is almost impossible to find a list of cities and towns of relatively the same size that have the same rates for electrical and gas service. Some companies that claim the cheapest rates really have established rates that are very cheap if there was any possibility of using enough electrical energy or gas to have the rate apply. The trouble is that you would never reach this rate nor could you carry a load factor great enough throughout the twenty-four hours. It will be found that some cities having water powers at their very doors are forced to pay higher rates than cities not so favorably situated. As an example, take Buffalo, N. Y. The city has spent to date from about $25 000 to $30 000 on a rate investigation and yet no relief is in sight. The question has been put up to the Public Service Commission of the second district. Meanwhile Buffalo, a city of 500 000 people, is paying in the neighborhood of $60 per h.p. per year, while towns across the river in Canada pay but $20 for the same service and incidentally for the same current.

From the power company's standpoint they always desire to embody a readiness to serve charge, with an overhead charge for a meter. Now if you use no current for a month or so, this charge would be legitimate because there is the meter they install. Then there is the time taken to read the meters by employees of the company and other charges that go on whether you use the current or not. To be sure, then, the small householder should pay a service charge. If current is used, the service charge is first used up at so much per kw. hr. and then the additional cost of current or gas is added. This, I believe, is proper and has been judged legitimate by the courts.

Now the company likes to tell the small man as well as the large one that a certain part of the machinery at the plant is reserved for his service, which is partially true, but this is only strictly true of the larger user who has a motor load. The larger consumer is relatively different from the smaller consumer. If your lights are on in the downstairs rooms they are not on upstairs, and vice versa, while the larger consumers are much more liable to use their total or full load. Undoubtedly there has to be a reservation made for a consumer who will have a load of say 10 kw. or more, for this would, if thrown on instantly by a number of such consumers, form a heavy demand on the

plant. Thus it will be seen that various classes of business will require different rates and plans of charging for them, varying as their demands on the plant vary. The small consumer is in a class by himself. Not often will he have a larger load than 1 kw. per hour, and if he is using this amount his neighbor's house is likely to be dark and thus a good diversity factor can be used. Ask yourself how many lights you burn in your own house at once and for how long. I shall now take up the various classes of rates.

Residence Rates.

Here the householder should be given a step rate on a simple basis so that he could readily see what he was paying for. If you tell him he will have to pay a certain rate on the instantaneous peak, on maximum demand or connected load, he is very apt to go around the house looking for one or the other. While, if you simplify matters and give him a certain rate until he uses a certain number of kw. per month and then another rate for anything in excess of the stipulated amount, he will stand some chance of understanding it, and he will not immediately assume that it is a new way for an electric company to get to his pocket book.

Therefore for this class of business let us fix as simple a scheme for charges as possible and maintain simply a readiness to serve charge, and make a charge per kw. which will be proportionate to the demand of this class of service on the plant. The rate should be kept as low as is consistent with the service, and just efforts should be made by the company to extend this class of business and so interest the people in building up the day load in their homes. For instance, there are small stoves, vacuum cleaners, motors for various purposes, flat irons, fans, etc., that would not affect the load on the plant so as to require new units of installation, but it would increase the income from this class of consumers an appreciable degree.

Commercial Light.

The customers falling under this class are the stores and offices and in reality should be divided into several different groups, as their demands on the plant are different. There are many business places, such as large dry goods houses, stores that are naturally dark, outer offices, cellars, etc., that require light all day. Then there are those who use the current, only at the

time of the peak load. While it is manifestly unfair to give all these classes the same rates for current they do receive the same price, although now there is an increasing tendency to place the business houses on a maximum demand meter and to charge a proportionally higher rate for this current.

Power Rate.

In this class there are also various subdivisions which have to be treated in different manner. We have an elevator load with its extremely bad power factor due to the fact that a large amount of power is required to start the machine and but a small fraction of the power required to operate it, due to the counterweights. There is, then, the continuous power required for driving motors, fans, pumps, and other power devices. As the operation of these devices takes varying amounts of power and they impose varying demands on the equipment at the plant, there should be a difference in the rates.

Thus it will be seen that there are a large number of computations which will enter into (the individual cost to serve) rates. There are numerous ways of determining these rates, but, on the other hand, there are a number of objections to each rate determination.

For instance, if we adopt the theory of use, we assume that each consumer shall pay proportionate investment charges for that portion of the plant which he uses. This is regardless of the fact that his use of current may be on or off the peak load, and it is also regardless of the portion of the time he uses the current. He therefore pays his proportion of the investment as divided among the total kw. hr. output of the plant for the year. This does not make provision for a proportionate charge to those consumers who cause a large investment and contribute but a small return to the general fund for the investment charge, such as elevators, or a charge for the off peak, or normal use load, which secures the benefit of the investment as well as that of the peak load.

If we adopt the theory of cause of the loads, then we would base our figures on the assumption that the investment made in the plant would be designed to meet the demand of the highest peak loads, and with this assumption the consumer's share of the investment charge would be in proportion to his peak load responsibility.

Thus it will be seen that the interest on the investment charge would be assigned to the peak load consumer, and the

customer who did not come on the peak would bear none of the burden of the investment charge.

There is also no practicable way of determining this peak, as it will vary between consumers of the same class and there will and should be class distinctions. It would also be extremely difficult to obtain data along these lines.

It will be found that even after making deductions of this nature there will still be lacking a relative earning value because of the constantly varying load factors which can be shown as offering a reduction in the investment on the plant. These load factors are continually changing within limits according to the class of consumers on the lines.

I have given you an outline of the various difficulties that confront the making and adjustment of rates, and I would now suggest that it would be well for the various commissions to adopt certain methods of gathering data, by the segregation of various feeder lines and by exhaustive tests and time charts, to determine and fix the peak responsibility of sections in the various residence districts, in mixed districts where residence and commercial light are used, and in the downtown districts where the main use is for commercial light and power.

These determinations will necessitate a large amount of research and will cost a considerable amount of money. But they should prove invaluable information for the fixing of the peak load responsibility and of obtaining the diversity factors of the various classes of business; the relative loads and factors for the various hours of the day could be tabulated and means devised by the power company for increasing these load factors.

With these figures as a basis and with careful research of the number of consumers of each class per square mile or any other unit of measurement, the relative costs of pole line and wiring, the readiness to serve charge and all other fixed or floating charges could be worked out, and if the different commissions, experts, and power companies would tabulate this data, and make it available, then any size plant could be figured out to a nicety, by making a study of population and the areas to be served, the class of service and the restrictions as to underground and to overhead service. Thus the capital required could be determined and a value arrived at for the relative cost to serve charges, the relations of each class of business to the other and the various responsibilities and charges to be made to each class of customers. With the large amount of data

thus obtained it would be no trick to tabulate it in form so as to figure out the following:

First, The manufacturing charge or cost of production of the electrical energy.

Second, The charge to the consumer. In this I mean the element of cost caused by the mere addition of a consumer to the line, including such items as bookkeeping, cost of reading meter, billing, collecting, etc.

Third, The charge to the investment, being interest on the investment, taxes, insurance, depreciation, etc.

Thus with the creation of a standardized system it would be hardly possible and no longer probable that large fictitious values could be created and the burden of this obligation placed on the consumer.

[NOTE.— Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 15, 1913, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

George Ferdinand Schild.

MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

MR. GEORGE FERDINAND SCHILD, member of the Technical Society, died at his residence in Vallejo, Cal., on the morning of March 25, 1913, at the age of sixty-nine years and seven months.

He was employed in the ship-drafting department at the Mare Island Navy Yard, and had been at work all the preceding day without any premonition of his sudden death. He died of an affection of the heart within an hour or two when the time came.

Mr. Schild was born at Trier (Treves), Germany, in 1844, and after attending the usual gymnasial and other preparatory schools exacted of the German youth, he took up the special study of shipbuilding, and passed his examination in due time as a *Schiffsbaumeister*.

As customary in his native country, the military requirements called for one year of his time. He chose the heavy artillery of the Prussian Army, and saw active service during the Austrian War of 1866, at the end of which he was made a lieutenant in reserve.

His employment at the United States Navy Yard dates from the year 1871, and for many years he remained a faithful and conscientious technical expert in the Construction Department. The drafting room has always been his field of labor, and his daily task was to work out the innumerable details that go to make up this or that feature of the great vessels of our navy. This he did as well when he was nearly seventy years old as when he was in the prime of his life, and his satisfaction lay in the knowledge that he had performed well his share of the work, whatever it may have been, with all the ability gained through years of ripe experience and faithful application to duty.

In fact, his whole life was a duty well performed. He was for some years the treasurer of the Technical Society of the Pacific Coast, before his brother succeeded him, and he was at one time the treasurer of the California Association of Civil Engineers.

THE LATE GEORGE FERDINAND SCHILD,
Naval Architect,
Past Director of the Technical Society of the Pacific Coast.

He leaves a wife, a former Miss Louisa de Mulder, of Cleves, and two married daughters.

His fellow-members of the Society deeply mourn the loss of one of their oldest friends and oldest officials. He was better known to the older ènginéers of California, who will cherish his memory until they, too, are called to join him.

ASSOCIATION
OF
ENGINEERING SOCIETIES.

Organized 1881.

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THE PROBLEM OF SMOKE ABATEMENT.

BY WILLIAM A. HOFFMAN, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, February 19, 1913.]

IN all large cities, especially of the central and middle west, the problem of smoke abatement is one of great importance and of general interest, as these cities are dependent for their industrial welfare upon the burning of soft coal. The experience of all cities has been that as the industrial activity increased, factories were enlarged, more power was required, more boilers added, usually another smokestack was erected and large volumes of dense smoke from the smokestacks were considered an evidence that there was plenty of business, that prosperity reigned. The constantly increasing volumes of dense smoke polluting the air caused our public-spirited citizens to desire its abatement, and their efforts were finally rewarded by this city's organizing what is known as the Smoke Abatement Department.

Smoke abatement is now considered by nearly all citizens a necessity, and smoke not, as in the past, a necessary evil. The damage resulting from smoke has been estimated in other cities at five to ten million of dollars per year, or about $12 per capita. This seems to be a large figure, but when one considers the cost of laundry, cleaning garments, cleaning draperies, curtains, carpets, etc., in the homes; the damage to fabrics and articles of manufacture, the damage to trees, shrubbery, outside woodwork, the polluting of the air we breathe, all of which affect to a more or less extent the individual, the householder or the manufacturer, it is surprising that the agitation for smoke

abatement has not been conducive of better results. This is accounted for by the prejudice and ignorance that existed and found expression in the oft-repeated saying that "soft coal could not be burned without making smoke." If this were true, most of the efforts for smoke abatement would be useless.

All large cities now have their smoke abatement organizations having for their object the cleaning of the atmosphere of the cities, making them desirable to live in as well as attractive to visitors. One of the many attractions of St. Louis is its beautiful homes, yet how long will they be an attraction if the city be covered and surrounded by smoke clouds? I have been told that what we need is more manufacturers, more smoking chimneys, not so much smoke abatement agitation. While the first mentioned is desirable, the second cannot long continue, because of smoke agitation, and as proof of this our strongest advocators of smoke abatement are those who previously were violent smoke producers. Almost daily do manufacturers tell us that they are in sympathy with this movement, saying, "We do not want to make smoke and be a nuisance to our neighbors; neither do we want to be annoyed with any other chimney producing smoke."

The smoke committee of the Cleveland, Ohio, Chamber of Commerce over two years ago gave a great deal of attention to this subject. It reported that the direct financial loss due to the smoke nuisance in Cleveland amounted to $12 per capita. In making this estimate the losses were considered under the following classification:

1. Domestic loss, or losses to the residences and their occupants.
2. Loss to retail stores.
3. Loss to wholesale stores.
4. Loss to offices, banks, etc.
5. Loss to manufacturers.
6. Loss to hotels.
7. Loss to libraries, museums and similar institutions.
8. Loss to hospitals and similar institutions.
9. Effect on health of persons, animals and plants.

After this report was made public, Chicago made an estimate as to the total damage done, and assumed that it was one third cleaner than Cleveland, which would amount to $8 cost per capita, and with Chicago's population the damage done would equal the sum of $17 600 000 per year.

Assuming the cost of $8 per capita and applying it to St. Louis, we have a financial loss due to this nuisance of $5 600 000 per year.

No estimate has been or can be made of the cost to each individual in having the air polluted with smoke and soot. Air is necessary for our existence. To breathe pure air is the right of every man, woman and child, and no man has any more right to contaminate the air we breathe than he has to defile the water we drink. He has no more moral right to throw soot about our homes or offices than he has to dump garbage on our premises.

It is now generally conceded that: First, dense smoke from bituminous coal is a nuisance; second, such smoke can in a majority of cases be abated; and third, such abatement can be made a source of profit to the owner of the plant as well as to the community.

The cause of smoke in St. Louis is, of course, the burning of bituminous coal, the greatest part of which is obtained from Illinois, within a radius of 10 to 50 miles of our city. That which is obtained from the immediate vicinity of St. Louis is of very low grade, of low heating power or B.t.u.'s, containing large percentages of ash and sulphur; of the former, sometimes as much as 20 per cent., and of the latter, 4 to 5 per cent. While other cities have their smoke abatement problem burning soft coal, I doubt very much if any have experienced the difficulties all users have had in eliminating the smoke while burning Illinois coal obtained in the vicinity of St. Louis. This is corroborated by those experienced in burning coal obtained elsewhere. The ordinary coal coming to St. Louis is the most difficult to burn properly.

The tonnage of bituminous coal consumed in St. Louis in 1910 was 7 598 394 tons. Of this 1 813 001 tons, or 23.8%, was used by the railroads, and 5 785 393 tons, or 76%, was used by corporations or citizens of St. Louis. Of the latter, that is, 5 785 393 tons, 3 471 235 tons, or 60%, was delivered to consumers in cars and 2 314 158 tons, or 40%, was distributed to power plants and the domestic trade by wagon haul.

No reliable data exist giving the quantity of coal consumed for domestic purposes, but a conservative estimate places this at 20 per cent. of the above, or 462 831 tons. The problem, then, is, How is this large quantity of bituminous coal consumed, and what efforts are being made to abate the smoke in the manufacturing and business section where 90 per cent. of the coal is used?

The problem of smoke prevention is the problem of perfect combustion, which is accomplished in the furnace and not in the boiler. Engineers now have sufficient information to enable them to design boiler furnaces that will burn soft coal without smoke. Heretofore, boilers were bought with no provision for its elimination; nothing but a boiler, a simple setting around the same and a grate on which to burn the coal. Now furnaces are designed with grates that admit the proper amount of air to burn the fuel, surrounded by good fire brick construction that absorbs and maintains a high furnace temperature, and provided with arches and baffles which also assist in maintaining high furnace temperatures as well as assist in the mixture of the air and gases.

Perfect combustion, therefore, is accomplished by the three conditions, namely, the proper air supply, the proper temperature, and the thorough mixing of the air and hydrocarbons, or gases.

Few realize the importance and necessity of the proper air supply; theoretically, it requires 12 lb. of air per pound of carbon, and it is considered good practice to increase the requirements 50 per cent.; we then must supply the furnace with 200 cu. ft. of air in order that enough oxygen be supplied to completely burn each pound of carbon. Yet how few furnaces are equipped to supply this amount. This air is usually drawn through the grate bars and fuel by the draft from the stack; invariably we find the grate bars covered with a heavy bed of fuel and accumulations of ash which prevent the admission of the air.

Next, the furnace temperature is usually not high enough to ignite the gases from the coal. It requires a temperature of 1 000 degrees to accomplish this, and finally the gases and oxygen from the air need to be thoroughly mixed and these gases maintained at a high temperature in order that combustion may be complete. All this should be done in the furnace before the products of combustion reach the boiler; the purpose of the furnace is to generate heat, the boiler to absorb it. There are certain boilers which could not have a fire-brick lined furnace, namely, the locomotive type and the internally fired boiler, yet these now have accessories which partly provide for the good features of the furnace just described.

In classifying plants, they may be divided into two general classes — mechanical stoker plants, and hand-fired plants. In the stoker plants we have the chain grates, the front and side feed inclined stoker and the underfeed stoker; and in the hand-fired plants, the down-draft furnaces, furnaces using steam jets

and furnaces with special settings such as arches, baffle walls, Dutch ovens, etc., which sometimes have steam jets and special features for admitting air to the furnace.

The smoke problem is taken care of in large power plants and manufactories by installing mechanical stokers; this is the best known method of smoke abatement, and there are various types.

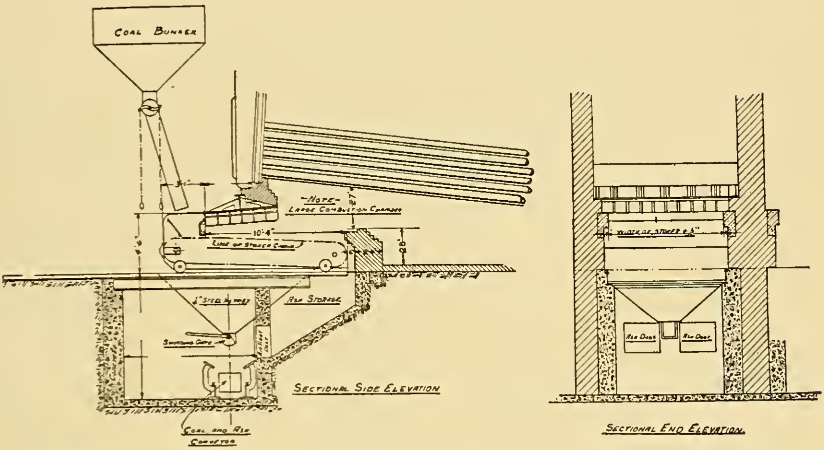


FIG. 2.—CHAIN GRATE SHOWING COAL AND ASH HANDLING ARRANGEMENT.

Mechanical stokers (see Fig. 1 and 2) are not installed for the sole purpose of abating the smoke, but for economic reasons. In large power-houses the coal is dumped from hopper-bottom cars into a receiving hopper, where it is conveyed to overhead bins in the boiler room, there spouted to the hoppers in front of the stokers; the coal is then advanced into the furnace and the ash is dumped into an ash hopper and then conveyed, usually by the same conveyor that brought the coal into the boiler room, into an ash storage hopper placed high enough to dump the ash directly into railroad cars. In such a plant the cost of steam generation is reduced to a minimum, a cheaper grade of fuel is burned and manual labor reduced.

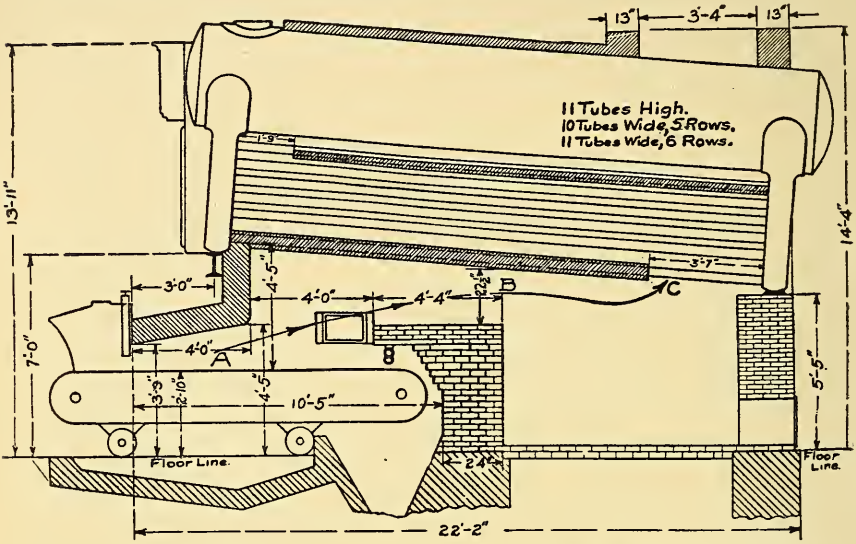
Fig. 2. The essential features for smoke abatement which argue for stoker installations are these:

1. The coal is fed into the furnace and the gases are distilled from the coal at a uniform rate.

2. The gases when distilled are brought into intimate mixture, with sufficient air to burn them completely.

3. The mixing is done under an arch and in a fire-brick chamber.

4. The gases usually are not allowed to touch the comparatively cool surfaces of the boiler until they are completely burned by having sufficient space and time to mix and burn in the combustion chamber. Fig. 3 and 4 show examples.



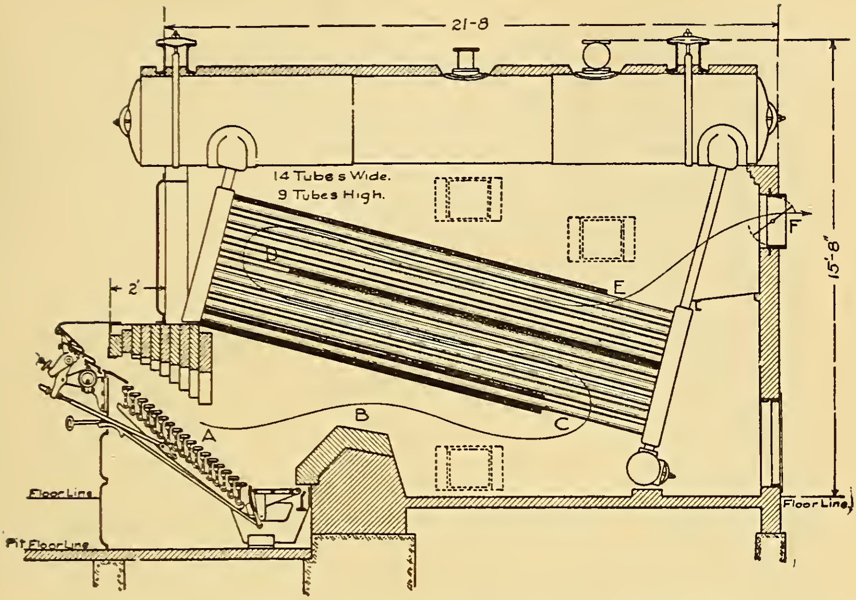
(Courtesy of the University of Illinois.)

Fig. 3.—Heine Standard, 210 H.P. Boiler Equipped with Green Chain Grate, Combustion Arch, Tile Roof Furnace, Adjustable Water Back at Bridge Wall.

You can readily see why the ordinary hand-fired boiler or the boiler or furnace used for heating in domestic service, which usually lacks one or all of the features enumerated, smokes.

The high first cost limits the application of the stoker. It must necessarily be confined to plants of large boiler horsepower; as plants enlarge, they will naturally discard the hand-fired furnaces and adopt the mechanical stoker. Some stokers are more applicable to small-sized boilers than others. There is a movement now under consideration by a well-known manufacturer of chain grate stokers to decrease the size, so as to make them applicable to small boilers. If this proves successful, there will naturally be more stoker installations in small plants.

Fig. 5. In the hand-fired plants the down-draft furnace is the most successful smoke-abating device. The late William H. Bryan in a paper on this furnace stated, " Probably no device



(Courtesy of the University of Illinois.)

FIG. 4.—BABCOCK AND WILCOX 220 H.P. BOILER, EQUIPPED WITH RONEY STOKER.

has done as much toward the practical solution of the smoke problem in St. Louis as the down-draft furnace."

We find these furnaces in power plants ranging from 100 to 2 000 h.p., in numerous office buildings, in nearly all the public schools, and of late in apartments, small hotels, churches, etc. Mr. M. C. Hawley of this city was the inventor of this furnace. Formerly it was known as the Hawley down-draft furnace. Mr. Hawley began his experiments in 1873. In 1882 the first suc-

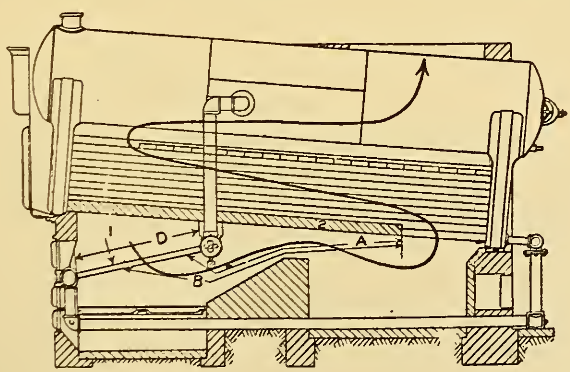


FIG. 5.—WATER TUBE BOILER WITH DOWN-DRAFT FURNACE.

cessful installation was made. I would not have you believe this at all times a smokeless furnace. It is apt to smoke during the cleaning period, or in the case of boilers overloaded, but it rapidly clears up, and it permits of more carelessness on the part of the firemen without emitting objectionable dense smoke than any other device.

The greatest number of hand-fired plants are equipped with steam jet devices, baffle walls and arches, for the reason they are the easiest to install and the cheapest in cost. These devices require more care on the part of the firemen to avoid making dense smoke. Devices of this kind in the hands of a careless fireman are almost worthless. The personal element is the greatest hindrance to progress in the abatement of smoke, and the skill of the fireman is the most important element with the ordinary equipment.

The department has more trouble with the hand-fired plants equipped as just described than with any others. So much dependence is placed on the firemen to operate the steam jets and to fire the coal properly, that is, fire more frequently and not too much at a time, that it will call for strict inspection on the part of the department and coöperation on the part of the operator and owner to keep these plants from violating the city ordinance.

Steam jet devices should be automatic, allowing regulation of both steam and air admission. They should mix the gases and air at the times of greatest need, that is, when coal is fired; after the volatile gases have been consumed, they should be shut off. I know of no reliable automatic steam jet device. When this is perfected, the steam jet will be in better favor.

The hand-firing of plain furnaces violates all the principles laid down for securing good combustion. The coal is usually supplied in large quantities at long intervals, and the result is that at the times of firing the temperature of the furnace is lowered, the resistance to the flow of the air through the fuel bed is increased, and consequently large quantities of combustible gases are generated which cannot be burned for lack of air and the proper temperature.

In all new installations for apartments, hotels, etc., boilers are being installed that have down-draft furnaces. Heretofore, the shell boiler with a brick setting was the only boiler with this type of furnace. Now cast-iron sectional boilers have down-draft furnaces, and these as well as shell boilers are being used successfully. Fig. 6 and 7 show examples.

Fig. 10.—Smoke Badly Needing Abatement.

Fig. 11.—Same Stack after Installation of Stokers.

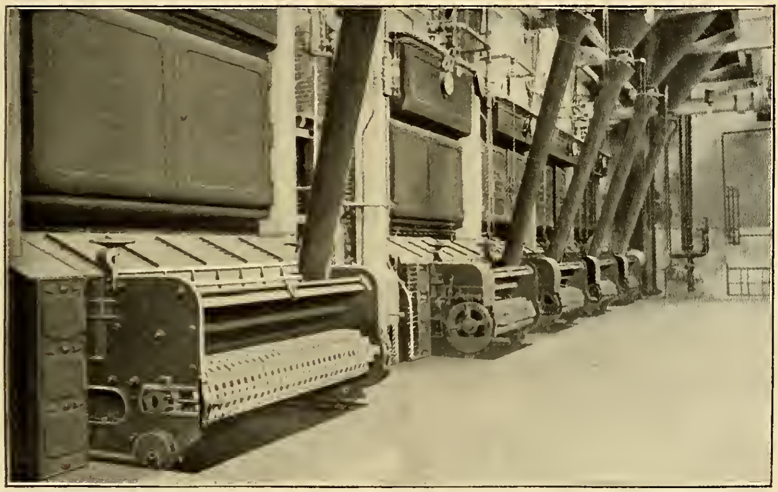


Fig. 1.—Chain Grate Fed from Overhead Coal Bins.

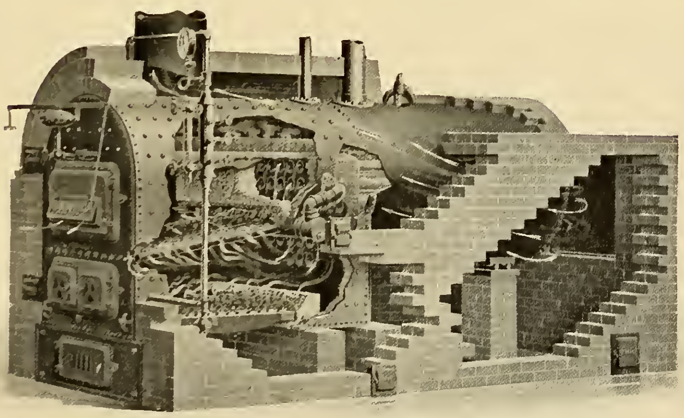


Fig. 6.—Sectional View, Smokeless Firebox Boiler.

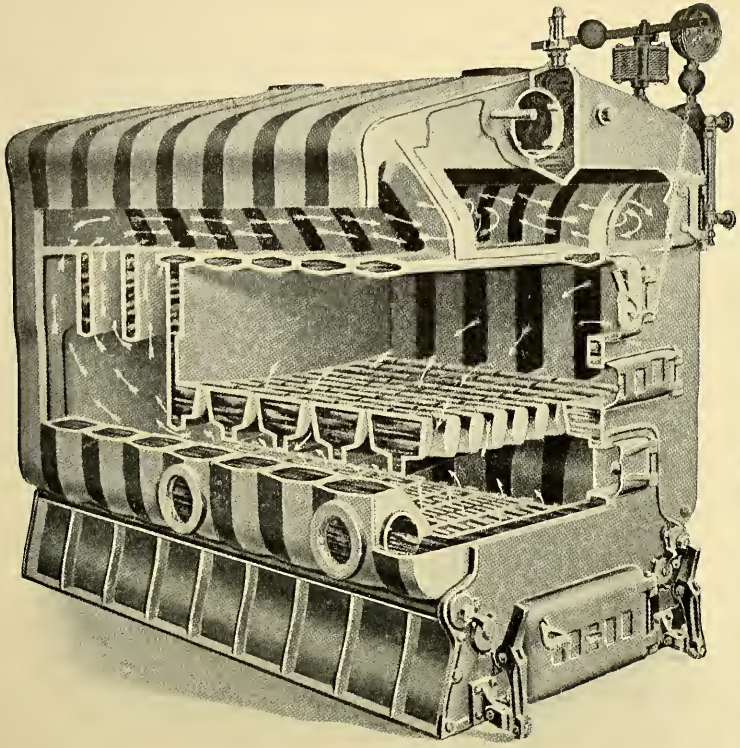


Fig. 7.—Cast-Iron Low-Pressure Heating Boiler, Down-Draft Furnace.

Fig. 8.—Locomotive Smoking, with Smoke-Abating Device Not in Use.

Fig. 9.—Ten Seconds after Fig. 8 was Taken (Device in Use).

In some cases groups of apartments are being heated by one central plant or furnace. This arrangement is both economical and convenient. Installations of this kind will greatly assist in the abatement of smoke in the residence sections.

By far the greatest number of residences and apartments have furnaces which cannot burn bituminous coal without causing smoke. There is no known device that can be applied to these furnaces. Hence, it will require a more general use of smokeless fuel if the residence sections expect to be free from this nuisance. Some have always used smokeless fuel. The success other cities have had in their efforts to abate the smoke, especially in the residence section, is due to the general use of this fuel.

For years the manufacturers of our city at no small cost have been installing smoke-abating devices. Often these devices were discarded because of their inefficiency. Installations of late years have, however, proven satisfactory, and if this be continued, St. Louis can rightfully say that it is making progress in the abatement of smoke. Every day violators are joining the non-violators. Even the railroads, who are responsible for a large part of the smoke of our city and who until recently made practically no effort to abate it, are now engaged in making changes on their locomotives whereby they can be operated without making objectionable smoke. There are some roads which have all their locomotives equipped with smoke-abating devices, and operate in and out of St. Louis without violating the city ordinance. The majority of the railroads have only part of their locomotives equipped; the remainder are being equipped as fast as the locomotives can be withdrawn from service. All roads are giving their firemen special instructions as to the method of firing. Special firemen and inspectors ride on the locomotives to see that their instructions are carried out. Notices of violations sent by the city inspector to the general managers and superintendents of railroads are taken up with the engine crew, and an explanation demanded as to the cause of the violation.

The public does not realize what the railroads have done; while it is encouraging to note the progress that has been made, there yet remains much to be done before the railroads as a whole make an impression as to their efforts for smoke abatement. With some roads it will be necessary to resort to the courts and assess fines before they realize that the city intends vigorously to enforce the ordinances.

The locomotive fire box is one of the most difficult places to apply and maintain a smoke-preventing device. The appliances that are being placed on locomotives in St. Louis are the best known devices, having been tried by the various roads in other cities. (See Fig. 8 and 9.) The trouble heretofore has been that each road desires the other fellow to make the experiments. The mechanical stoker has been tried and abandoned because of difficulties of operation and maintenance. At present the best known device consists of steam jets in the firebox with an arch over the fire to maintain a high fire box temperature, and a stack blower.

The department in estimating the relative blackness or density of smoke uses what is known as the Ringlemann method. This system was invented by Professor Ringlemann of Paris, and is in general use throughout the world. The United States Geological Survey and all the large cities of this country have adopted this as a standard.

The ordinance under which the smoke department operates states: "That the emission or discharge into the open air of dense smoke within the corporate limits of the city of St. Louis is hereby declared a public nuisance." The department considers the term dense smoke to mean smoke that cannot be seen through as it leaves the top of the stack or chimney. This corresponds to the numbers 3, 4 and 5 of the Ringlemann system. The lighter shades, numbers 1 and 2, are exempt from the activities of this department.

It might reasonably be asked what is the present organization and what are the means and methods used by the city of St. Louis in making efforts for smoke abatement.

By an act approved by the Municipal Assembly, Ordinance No. 20583, approved March 24, 1901, there was created a smoke abatement department to carry out the provisions of the act of the general assembly of the state of Missouri relating to smoke abatement in cities of one hundred thousand inhabitants. The ordinance authorized the appointment of a chief smoke inspector and five deputy smoke inspectors.

Ordinance No. 24753, approved January 19, 1910, repealed Ordinance No. 20583, and charged the inspector of boilers and elevators with the duty of carrying out the provisions of the act of the General Assembly. The inspector of boilers and elevators was charged with this extra duty without additional assistance being given him. It was to be expected therefore that in carrying out the provisions of the ordinance the lack of men to properly

do this work would soon manifest itself. In his reports my predecessor in office complained as to the poor facilities he had to carry on the work, particularly the lack of men.

Reports of smoke violations were sent to him through the mails, and he found that he was unable to properly investigate the complaints because of the work required of his deputies in inspecting boilers and elevators. He therefore attempted to meet the emergency by mailing form letters, making complaint of the violations, requesting that the violator comply with the city ordinance. The results of this plan were only partially successful.

His evidence for court cases, that is, photographs, were prepared by a photographer from the Street Department.

The writer on taking charge of this department soon realized the weakness of the inspection system, reported the same, and was given the assistance of four inspectors furnished by the Water Department. These inspectors make all smoke stack observations, investigate complaints and collect evidence for court cases. Photographs are taken by a photographer from the Street Department.

For our convenience the city is divided into four sections, the North, South, Central and the West, with an inspector in each, who daily walks through a portion of his district making stack observations and investigating complaints. The latter vary in character from a legitimate complaint to a back yard quarrel in which the department is appealed to for redress, or the department is expected to alleviate the suffering of individuals, as in the case of one elderly lady, who last winter complained to the writer that she had asthma and having heard of the Smoke Abatement Department, requested that an inspector call and see what could be done to prevent the escape of gas from her heating stove. The inspector called and, finding the stove pipe full of holes, recommended a new stove pipe. The inspector's recommendations must have been complied with, for I since have heard nothing from the old lady with the asthma.

During the past year these inspectors have made about 5 000 stack observations and 1 200 what are termed special visits, usually being the investigation of complaints. The department notified 1 803 firms and individuals of the report of the inspectors' special visits, and of smoke violations. These reports gave in detail the nature of the complaint and suggested the remedy therefor. In the case of observations of a smoke violation, the extent of the violation, that is, minutes of dense

smoke observed, was given, and the duration of the observation, which is usually one hour.

The department wishes to coöperate with the smoke violator, appealing to him to assist in the abatement of smoke and offering him any assistance that we can render. Contrary to the general impression, there has been considerable work accomplished in abating the smoke without the necessity of bringing the offender into court. During the past year there have been at least two hundred cases where devices have been installed through the efforts of the department, and prosecution was not necessary. There have been 499 cases recorded that have complied with the smoke abatement law without prosecution, 299 of these being voluntary.

There is a reason for a violation where smoke-abating devices have been installed, and the department accepts a reasonable explanation as to the cause of the violation. Usually two or three notices are sent to a violator. If no attention is paid to these, evidence is collected for court proceeding.

During the year there have been:

Court cases filed	124
Cases won	85
Cases lost	7
Cases nol pros.	13
Cases pending	19
Total	124

In every case where cases have been won, there has been a satisfactory device installed. All the won cases have been dismissed on the payment of costs, usually $6 to $8. We have had only two cases where a fine of $100 was assessed. The court waived the fine when the violator installed a device. Smoke abatement is what we are striving for. The payment of fines, of itself, will not accomplish it.

Few persons realize the work that the department does to accomplish smoke elimination.

The following is an illustration:

A certain large manufacturer was notified that on January 29, 1912, during an observation of one hour, eleven minutes of dense smoke was observed coming from the chimney of his factory. On July 2, 1912, another notice was sent to him of a like violation. The answers to the department's communications having been unsatisfactory, and the chimney continuing to emit dense smoke, the case was prepared for court, the evidence

offered being an observation of the stack and photographs. After the case was cited in court, the defendant's representative called upon the writer asking advice as to what could be done to eliminate the smoke. The representative was informed that the boiler and furnace installation would be examined and the department's recommendations as to changes would be sent to the owner. A study of the installation was made, and a sketch of furnace changes was sent to the owner, who immediately had one of the furnaces changed as suggested by the department. Another stack observation was made on the boiler with the reconstructed furnace. No dense smoke was observed during an observation of one hour. This report was sent to the owner, who immediately proceeded to make the same furnace changes in the other boiler. This plant now operates without making dense smoke.

	Furnace Installations.	Power and Heating Plants Installed from April 10, 1911, to April 8, 1912.
Down-draft boilers	789	129
Chain-grate stokers	277	95
Incline	106	30
Underfeed	16	4
Spray-feed	3	—
Dutch ovens	13	7
Arches only	25	9
Baffle walls only	21	16
Steam jets only	378	111
Arches and steam jets	43	18
Baffle walls and steam jets	181	114
Baffle walls and arches	14	12
Plain furnaces	289	7
Cast-iron down drafts	179	89
Cast-iron plain furnaces	196	46
Vertical boilers	379	51
Haxton boilers	45	16
Smokeless fuel	150	82
Oil and gas	5	2
Total	3,112	838

Railroads.

The department has been active in making observations since January 2, 1912, of smoke violations by the railroads. Up to the present time there have been 20 101 observations made

of the various locomotives operating in and out, and within the city of St. Louis.

In this period there have been 3 406 violations reported, or 16.9 per cent. of the total. These violations have all been reported to the heads of the railroads responsible for them. The reports give in detail the road to which the locomotive belongs, its number, the date, and where the violation occurred, the point of observation, the total time of observation, the number of minutes of dense smoke emitted during that period, and the service indicated, such as passenger, freight or switching.

The reports are such that the officer receiving them can make an investigation of the violation, which he usually does by demanding of the engine crew a cause for the complaint.

Table A.

	Observations.	Violations.	Per Cent. Violations.
January, 1912	1 222	534	43.7
February	1 101	236	21.4
March	349	20	5.75
April	1 270	327	25.4
May	2 406	445	18.5
June	2 921	479	16.4
July	2 705	422	16.8
August	2 691	308	11.5
September	1 451	141	9.7
October	1 116	159	14.4
November	810	86	10.6
December	978	128	13.0
January, 1913	1 111	121	10.8
Total	20 101	3 406	16.9

There are 490 locomotives operating in and out of St. Louis. On about fifty per cent. of these devices are installed which if properly operated will prevent the emission of dense smoke.

It is my opinion that satisfactory results will not be obtained until every locomotive is equipped with a substantial smoke-abating device. This has been found necessary in our manufacturing districts, and I know of no reason why the results of that experience should not apply to railroads.

In reviewing the work done by the city Smoke Abatement Department, while realizing much work yet remains to be done, we find that progress is being made not only in the abatement of smoke, but also in the coöperation of those responsible for it. Coöperation is a valuable asset. Without it, the department is

handicapped and progress is necessarily slow. It was particularly gratifying to note at a recent public meeting where the new ordinances relative to smoke abatement were discussed and at which representatives of all industries were present, the desire of all manufacturers was to abate smoke, the only difference of opinion being the amount of smoke to be permitted.

It is often stated that we should not lose sight of the fact that St. Louis is in a cheap soft coal district, that cheap coal has been the means of inducing manufacturers to locate here, and that if, after locating, stringent laws are enforced requiring the abatement of smoke, rather than be persecuted, they will go elsewhere. I consider that the enforcement of a smoke abatement law ought not to deter or hinder a manufacturer from locating in this or any other large city. Our manufacturers are meeting the problem in competition with others and if they desire to locate in any other large city, they will find a smoke abatement law.

We are also told that we ought not to disturb the soft coal interests in the immediate vicinity, intimating thereby that due to the laws for smoke abatement consumers will go elsewhere for a different grade of fuel. It does not appear that the soft coal operator has suffered either in the price of coal or the disposal of his tonnage. The use of mechanical stokers has enabled him to dispose of slack and small-size coal which was formerly left at the mine; his lump coal is cleaner, — he can, and does, command a higher price for it. For your own information, look at the next load of lump coal passing. If you could examine it, you would find no slack or dirt, and very little small-size coal. Quite a difference between that which is now delivered and that delivered three or five years ago, and sold under the same name or grade! There is a constant demand for screenings, and the users of mechanical stokers thereby secure a cheap fuel. The user of lump coal is getting a cleaner coal. The coal operator has no dump at his mines now; he sends to the market all coal that is mined, and secures a fair price for all his product.

That progress is being made in smoke abatement in the city of St. Louis is the opinion of those competent to judge and compare results. (See Fig. 10 and 11.) The smoke stack of a plant is usually very prominent, and when citizens see it pour forth the volumes of dense smoke, they wonder and complain of the delay in making all smokestacks cease to be smoke violators; they do not realize that it takes time to do this. There are about 2 200 smokestacks in the city. Neither do they

realize the difficulty some manufacturers have in abating the smoke.

Progress in smoke abatement will always be greatest where most of the fuel is used, that is, in the business and manufacturing section where there will be a continual development from the hand-fired furnaces to the mechanical stoker.

Hotels, office buildings, apartment houses, churches, schools, etc., will use down-draft furnaces or other known smoke-abating devices.

In residences where devices cannot be applied, we must expect a more general use of smokeless fuel.

Statistics indicate an increasing use of smokeless fuel, in 1911 the tonnage of anthracite coal alone being $67\frac{1}{2}$ per cent. more than in 1910.

DISCUSSION.

Mr. Hunter. — Is that boiler (low-pressure heating boiler, Fig. 6) designed for that furnace?

Mr. Hoffman. — The boiler designed for a down-draft furnace, do you mean?

Mr. Hunter. — Is the boiler designed for capacity; otherwise if you are installing that furnace, the boiler would be reduced in evaporation very materially.

Mr. Hoffman. — We have had extended tests on heating boilers; the coal burned per sq. ft. of grate surface compares very favorably with what one would expect, — say 12 lb. of fuel per sq. ft.

Mr. Hunter. — Is the device in action? (Smoking locomotive, Fig. 8.)

Mr. Hoffman. — The device is in action now (Fig. 9), eight seconds after the other picture was taken. There is one feature here to bear in mind, and that is there is no load on this engine. That is, it is not pulling any load, but the smoke can be decreased considerably. The latest locomotive, having superheaters with this Parsons device and an arch over the grate, will pull forty to fifty cars up the steepest inclines we have in and about St. Louis with hardly any smoke being observed from it.

Mr. Hunter. — Gentlemen, you have heard Mr. Hoffman's very interesting paper and I am sure he will be glad to answer any questions that might be asked in connection with his work.

Mr. Tenney. — I had the pleasure of looking over Mr. Hoffman's paper a few days ago and I have taken the opportunity

to write down a few remarks that I would like to make at this time.

The popular idea of smoke elimination seems to be that of some device placed in the stack which will in some mysterious way consume the smoke. Such a method may be possible, but does not seem to be practical. Mr. Hoffman has very clearly brought out the scientific and at the same time practical method of eliminating smoke, namely, by such design of the furnace as shall permit of the intimate mixture of sufficient air to completely burn the gases liberated from the fuel, this mixture to take place in a highly heated furnace chamber and the combustion to be completed before the gases reach the cooler surfaces of the boiler. The brick lining and arches suggested by Mr. Hoffman, with perfect baffling, when brought to a state of incandescence, have more to do with the entire elimination of black smoke than anything we know of in the market that deals with smoke consumption. The cooling of these arches through change of load or cleaning of fires has a tendency to make smoke until such time as they become incandescent again.

I think we all agree with Mr. Hoffman that smoke is a nuisance, that it can be abated, and that its abatement may be a source of profit both to the community at large and to the owners of the plants directly involved.

As to the profits to be derived from the elimination of smoke: the additional expenditure per capita of $12 per year referred to in Cleveland from smoke conditions would, if the same figure were applied to St. Louis, amount to $9 000 000. (This loss, I understand, in the Cleveland report is estimated to be for increased expenditures for repairing and repainting exteriors and interiors of buildings, for artificial light made necessary by the decreased amount of sunlight, and for laundering and cleaning and for injury to vegetation.) *The profit to be gained by the power plant owner* in the elimination of smoke may be a very substantial one. The fact of the smoke itself, that is, the actual black particles of carbon seen coming out of the stack, is not worthy of great consideration from the standpoint of economy, — the loss in the heating value of the fuel seldom amounting to 1 per cent. from this source, — but it is the incomplete combustion of the gases, indicated by the accompanying black smoke, that is worthy of the serious consideration of the power station operator. This loss — from carbon incompletely burning to carbon monoxide and from unburned hydrogen and hydrocarbons — may amount to 20 per cent. of the heating value of

the fuel. (My authority for this statement is Mr. S. B. Flagg, of the Bureau of Mines.)

In a large power station like that of the Union Electric at Ashley Street, where furnace and smoke conditions are extremely satisfactory when the boilers are operating at full load, the principal cause for the small amount of smoke which still exists is the wide and continual fluctuation in the load. Where the steam pressure must be kept constant, a changing load means that the fires must be increased or decreased in their intensity according as the demand for steam has changed. To care for such fluctuations, we continually operate four or five boilers for regulating steam pressure even during those parts of the day when the load is most constant. These boilers are operated at various rates of combustion by changing the position of the damper and the speed of the grate in such a manner as to maintain a steady stream pressure on the main header leading to the generating units. During heavy or peak load periods more boilers must be brought into the load, and after such periods they must be taken off, and each such move involves more or less of smoke and a large loss in boiler efficiency. The cause of the smoke is short fires and the consequent excess air which tends to cool the gases and prevent them from burning, causing smoke and at the same time carrying off to the stack a large amount of heat.

Mr. Ockerson. — I would like to ask Mr. Hoffman as to the type of device used by the Terminal Association. Is that a steam jet?

Mr. Hoffman. — On their locomotives, yes, it is a steam jet device, known as the Parsons device.

Mr. Ockerson. — It is satisfactory in its operation, isn't it?

Mr. Hoffman. — Yes, sir.

Mr. Ockerson. — Has it been applied to any stationary plants?

Mr. Hoffman. — It has been applied to some stationary plants. The Terminal Association has it in three of its plants, there are two in other plants, five installations in all.

Mr. Ockerson. — I saw in the bulletin from the Bureau of Mines a short time ago a statement that that Bureau intends to take up the matter of the elimination of smoke in cities. I do not know just how that comes into mining operations, but it seems it is their intention to go into the study of it and determine what should be done and then announce just what cities ought to do to be clear of smoke. I have enjoyed the talk very much,

particularly the pictures, except that I was disappointed that we did not have a picture of the stacks in Mr. Hunter's plant when they were smoking.

Mr. Hunter. — I might answer that. Our condition, of course, is rather an unusual one, our loads vary so much and we are changing boilers so often, due to that load. In our Central Station at Ashley Street we have 52 boilers, 500 rated capacity, that are working, at the peak of the load, at 175 per cent. Between 12 and 5 o'clock in the morning, we have five boilers carrying the load. That is due to the load being low. Then at 5 o'clock in the morning it is necessary to bring on twenty boilers and, while the smoke isn't noticeable at that time, I assure you there is some of it going on because our brick setting is cold, and until that setting becomes incandescent it is impossible that it should be otherwise, even in the boiler shown on the screen, that Professor Breckenridge said was the only method he knew of that would entirely consume the smoke. In bringing on a boiler that has been on bank for six or eight hours, where the tile has become cold, it will smoke. You cannot prevent it. Then in the evening again, when our load runs high, between three and four in the afternoon, it is necessary to bring on fifteen or sixteen more boilers. Now that is the time that we make the most smoke, with less at noon time when the load drops off and it is necessary to check the capacity of the boilers. They have got to be banked. Under those conditions you will make just as much smoke because the proper amount of air is not admitted to the furnace for proper combustion. I have asked a great many professors if there were any possibilities of improving our installation and I have understood that, burning the class of coal that we do, it is impossible to improve the conditions otherwise than as we have, and I can assure you that if it were possible to do so our company would willingly make that change, and has directed me to do everything possible; but, up to this time, I have not found anything that will relieve the condition with the varying load.

Mr. Smith. — I would like to ask Mr. Hoffman whether or not the Terminal people have made any tests as to the relative efficiency of a boiler equipped with this steam jet device.

Mr. Hoffman. — Your question, Mr. Smith, was whether the Terminal people had made any tests?

Mr. Smith. — Well, not particularly the Terminal people. I referred to locomotive boilers.

Mr. Hoffman. — No, I never heard of any, but the railroad

people as a whole are paying more attention to the combustion process. As I stated in the paper, they have appointed expert firemen to ride with their crew and instruct them in the manner of firing. Another point is that the railroads are watching the coal pile more closely now than they ever did before. On the Northwestern Railroad they know how much coal ought to be fired on a locomotive between certain division points, running, say, 150 or 200 miles. I do not know of any tests applied to a locamotive; unless this might be interesting to you. It is the word of the Superintendent of Motive Power of the Chicago, Burlington & Quincy Railroad when he spoke of arches. He said that they figured that an arch which stood up for a thousand miles had paid for itself, but, he says, We get five thousand out of it.

Mr. Smith. — That was the point I had in mind. I knew they were being watched closely and I thought any device of this kind would prove attractive if it was shown that there was no decrease in the efficiency; in other words, if it costs no more to operate.

Mr. Hoffman. — There is another feature developing in railroad practice and that is the use of superheated steam. The last fifteen locomotives purchased by the Terminal Association have superheaters which cut the coal down 25 or 30 per cent.

Mr. Hunter. — What percentage of the steam generated is required for such a device as that? (Parsons device on locomotives, Fig. 9.)

Mr. Hoffman. — I never heard of a test being made on that. In stationary practice, I have tested steam jet devices where we used only $2\frac{1}{2}$ per cent. of the steam generated to supply the steam jets, but I believe the average steam jet would use 5 to 10 per cent., — about 8 per cent.

Mr. Fish. — The figures that are given as the loss by smoke, I used to take with a grain of salt. Of course, it is impossible to say how much it is, but they indicate that there is a great loss from that source. People in general, I think, do not understand that the term "smoke consumption" is entirely a misnomer. The term "smoke prevention" should be used. Smoke once made is impossible to get rid of except through a smokestack. You have to prevent the making of smoke to prevent the emission of it from the chimneys. Most engineers who are not engaged in boiler or power-house practice do not realize the great variety of conditions that have to be taken into account in determining what shall be done to prevent the making of smoke. It isn't a simple problem; it is one of the most complicated

problems that the boiler and furnace men have to go up against. Each plant has to be considered on its merits. There is no one general condition that is applicable to every plant. You cannot make any one thing that will meet all the conditions, consequently it seems to me that the attempt to regulate the making of smoke should be governed largely by the rule of reason. So long as we use soft coal, and we are going to continue using it in this locality for a great many years to come, I guess, we are going to have more or less smoke. There are times when it is simply impossible not to make some smoke. There can be a great deal done, and there has been a great deal done to lessen the amount, but so far as its absolute prevention is concerned I think that is an impossibility. In power plants you can do it very much better than you can when soft coal is used for domestic purposes, but that does not mean, of course, that we should not continue to use every endeavor possible to make as little smoke as possible, both from an economical and a civic standpoint. The use of Keokuk power, of course, is going to do a great deal; I presume it will lessen the difficulty at Ashley Street and might possibly help out a great many of the small plants. In fact, I have no doubt it will, in many ways, be a good thing; but many of the plants have to use coal for heating, for the electric power is not economically suited for heating at the present time.

MR. GARRETT. — Isn't it a fact that the most objectionable smoke comes from residences?

MR. HOFFMAN. — No, I think not. I think it is merely that we see it more. When we get up in the morning we look out of the window and see a couple of those chimneys, and we forget all about the Union Electric down town, and by the time we get down town the Union Electric is all warmed up; you must consider the volume that is being made by the large coal users. Another point that will always make it hard for us to insist on the burning of smokeless fuel is its cost. In Chicago, Cincinnati and Indianapolis they advocate smokeless fuel in the residence section. They can do so with grace because their smokeless fuel only costs about $4 to $4.50 a ton, and in St. Louis it costs $6. Here is another point. There is hardly more than 400 000 tons of coal consumed in domestic trade, while in the manufacturing plants there is about five million tons consumed in the whole city. No doubt there is a difference in the degree of efficiency, as far as the amount of smoke is concerned, but nevertheless there isn't a sufficient ratio that will offset the difference in the amount of coal used. Another point; it will

take a domestic fire, after it has been established, fifteen to twenty-five minutes to clear up, whereas a power plant will sometimes clear up in less than a minute.

Mr. Garrett. — That is the point. There is more than 50 per cent. as much smoke made in domestic plants.

Mr. Hoffman. — A year ago, all the smoke violators that were brought to court by the City Department were for violations of fifteen to twenty-five minutes or more per hour. To-day, we can hardly find a plant that will smoke ten minutes per hour for us. I do not think the average of violations will reach six minutes.

Mr. Garrett. — Not on the residences?

Mr. Hoffman. — On the residences it will be fifteen to twenty minutes. I think there is an economical question for the residences, and that is to consider the different grades of coal. Of course, I do not believe we can expect a poor man to buy a high-grade fuel. That will be impossible.

Mr. Garrett. — That is just where the trouble is coming in.

Mr. Hoffman. — That is the source of a great deal of complaint down town, especially where you find, say, a two-story building next to an office building of six or more stories, and they have these little fellows sending smoke through their windows.

Mr. ———. — I would like to ask if there are any down-draft furnaces in East St. Louis.

Mr. Hoffman. — We are hoping that East St. Louis will see the contrast some day and get busy.

Mr. Metzger. — Where do you get a smokeless coal at $6?

Mr. Hoffman. — The West Virginia semi-bituminous coal, sold here in St. Louis as Pocahontas, or Admirality grade; it is $2 cheaper than your hard coal, that is, Pennsylvania anthracite. It has about 3 per cent. ash. I should say it has from one half to one third less ash than Pennsylvania anthracite, and in its heating effect it is very much like our bituminous coal in that it heats up very quickly. It is very rich in carbon, containing from 75 to 77 per cent.

Mr. ———. — Is it possible to start a down-draft furnace without making any smoke? That is, can you take a cold boiler, start a fire under it and get steam up on it without being pounced upon by the smoke inspector or one of his deputies?

Mr. Hoffman. — I would say no, it isn't possible to start a down-draft furnace without making dense smoke, such smoke that perhaps one of our inspectors would stop and take a picture

of it, but it was my observation to witness a test of a down-draft heating boiler in which I think there were only three or four minutes of dense smoke of the lightest shade made, in bringing a down-draft furnace up from a cold condition.

Mr. Fish. — How big a boiler was that?

Mr. Hoffman. — A boiler of about 3 000 sq. ft. of radiation similar to Fig. 6. It supplied heat to a factory about five stories high having a frontage of 75 ft. and a depth of 110 ft. I was really surprised at that performance. Our department never pay any attention to the starting of a fire. We know that you cannot start a fire without making dense smoke.

Mr. Hunter. — In a plant the size of ours it is necessary each day to put on possibly four or five boilers, which have to be taken off for cleaning purposes, and it would be impossible, even with your down-draft furnace, to start that boiler without making some smoke.

We have with us to-night a gentleman who is very much interested in this subject, and he has been invited to say a few words to us. I would like to ask Dr. Moore from the Botanical Garden to speak on this subject.

Dr. Moore. — It is getting pretty late and I do not believe that you care to be distracted from the practical side. Reference has been made to the effect of smoke, or the obnoxious fumes that are conveyed with the smoke, on vegetation, and it must be admitted that a considerable amount of damage can be done, particularly from the sulphuric acid formed, or a combination of various things which may be distributed through the smoke stack. However, I am inclined to think that the damage done to vegetation by smoke has been somewhat over-estimated. It is pretty easy to blame the smoke for the death of a tree that has not been properly planted in the first place, and there are a great many things that have to be taken into account. Illuminating gas in the soil kills a great deal of vegetation the death of which is credited to smoke. Of course, we say that certain plants are very susceptible to the SO_2 that is formed, and there is no question about it. There is some dispute, however, as to whether it is poisonous to plants. Some claim it is the hydrogen, but investigations in this country and in Europe seem to show that it is the SO_2, which, of course, soon becomes sulphuric trioxide. Now a plant normally has a certain amount of sulphuric acid in it. That is, you can analyze a plant and determine that there is a low percentage of sulphuric acid in it, although it may grow a thousand miles from any smoke. This

was worked out, particularly in the Anaconda case, the Government's case against the Anaconda Copper Company, with a great many witnesses on each side. At that time a great many analyses of leaves were made, showing the amount of sulphuric acid, and it seemed to show that those plants which were subjected to sulphur fumes contained a very high percentage. Almost everybody believes that the damage is done through the leaf. I am inclined, personally, to think, in spite of the fact that we do not find free sulphuric acid in the soil, that a considerable amount of damage from smoke may be done through the soil. Out at Shaw's Garden, we are going to try to grow plants in spite of the smoke. Some of the evergreens are rather susceptible to the action of smoke. The junipers will stand a surprising amount of sulphuric dioxide, and no two plants react in the same way to the same poison, although they may be closely related. One plant growing under favorable conditions can resist it when another one cannot. I am not trying to mitigate the smoke nuisance by indicating that it isn't capable of killing all the vegetation on the face of the earth. There are enough evils that smoke is responsible for, but I do believe that laying blame for all the damage that is apparent to the naked eye to trees and permanent vegetation, particularly evergreens, — those which bear their leaves through the entire twelve months, — laying this all on the smoke of the air, is wrong.

Mr. Greensfelder. — I would like to ask Mr. Moore what makes the sycamore the most hardy tree in this vicinity.

Dr. Moore. — I do not think the sycamore is any more hardy than the sweet gum. There has been a series of experiments with trees which are supposed to be very susceptible to smoke, and in running through the list you get to the maple first. The sycamore is not the most hardy tree. Some of the pines and spruces are most susceptible, but those are conditions which are difficult to account for. There is no actual explanation for it. In the same way, we have plants growing in the water some of which will stand 100 or even 1 000 times greater dose of poison than another plant growing in the same water, it being a question of the action of the poison itself on the individual cell, and we really haven't any explanation for it. As far as the sycamore is concerned, the fact that it sheds its leaves is an advantage and makes it one of the most hardy. The elms have a good many pests that infest them, and the same might be said of the maples, from which the sycamore is free. As far as the effects of smoke

are concerned, they are not as severe on the sycamore as they are on the other trees.

Mr. Greensfelder. — Is the European sycamore supposed to be as hardy as the ordinary sycamore?

Dr. Moore. — We haven't had much experience with it, but when a tree of that kind is brought in it is better taken care of than the ordinary tree. Our comparisons are not fair in this instance.

[Note.— Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1913, for publication in a subsequent number of the Journal.]

A SMALL BASCULE HIGHWAY DRAW SPAN.

By L. E. Moore, Member Boston Society of Civil Engineers.

[Read before the Society, February 19, 1913.]

Most civil engineers look upon a movable bridge as a bridge pure and simple, with certain machinery for operating it as an adjunct to the bridge. This point of view often leads to designs which are unnecessarily expensive to maintain and in which facility and cheapness of operation are subordinated to certain theoretical considerations which are often given undue importance. It seems to the speaker that the proper point of view to take with reference to movable bridges is that they are machines, existing, it is true, only because of the demand for a bridge at some particular location, but designed primarily with a view to cheapness of maintenance and operation as machines, as well as reasonable first cost.

The most important consideration in designing a machine is that it should be as simple as possible, that is, it should contain as few moving parts as possible, and these moving parts should be so arranged that they will not readily get out of order. It should also be, as far as possible, fool-proof.

In the bridge which I shall show you to-night, I will ask you to take so far as possible my point of view and consider this structure as one which was designed as a machine rather than primarily as a bridge.

In the summer of 1911, the writer was engaged by the George M. Bryne Company to design a draw span as part of a bridge which they had contracted to build for the town of Barnstable. The contract provided that the bridge should be built in accordance with certain plans furnished to the contractor, and contained the provision that the contractor should furnish the design for the steel draw span and build it subject to the approval of the town's engineer. The bridge extends from the mainland to Grand Island in the village of Osterville, in the town of Barnstable, and replaces a wooden pile structure which contained a double leaf wooden stringer draw span of the type found quite commonly in this vicinity.

Fig. 1 is a general view of the completed structure. It consists of four 42-ft. spans of the concrete girder and slab type

Fig. 1. Grand Island Bridge.

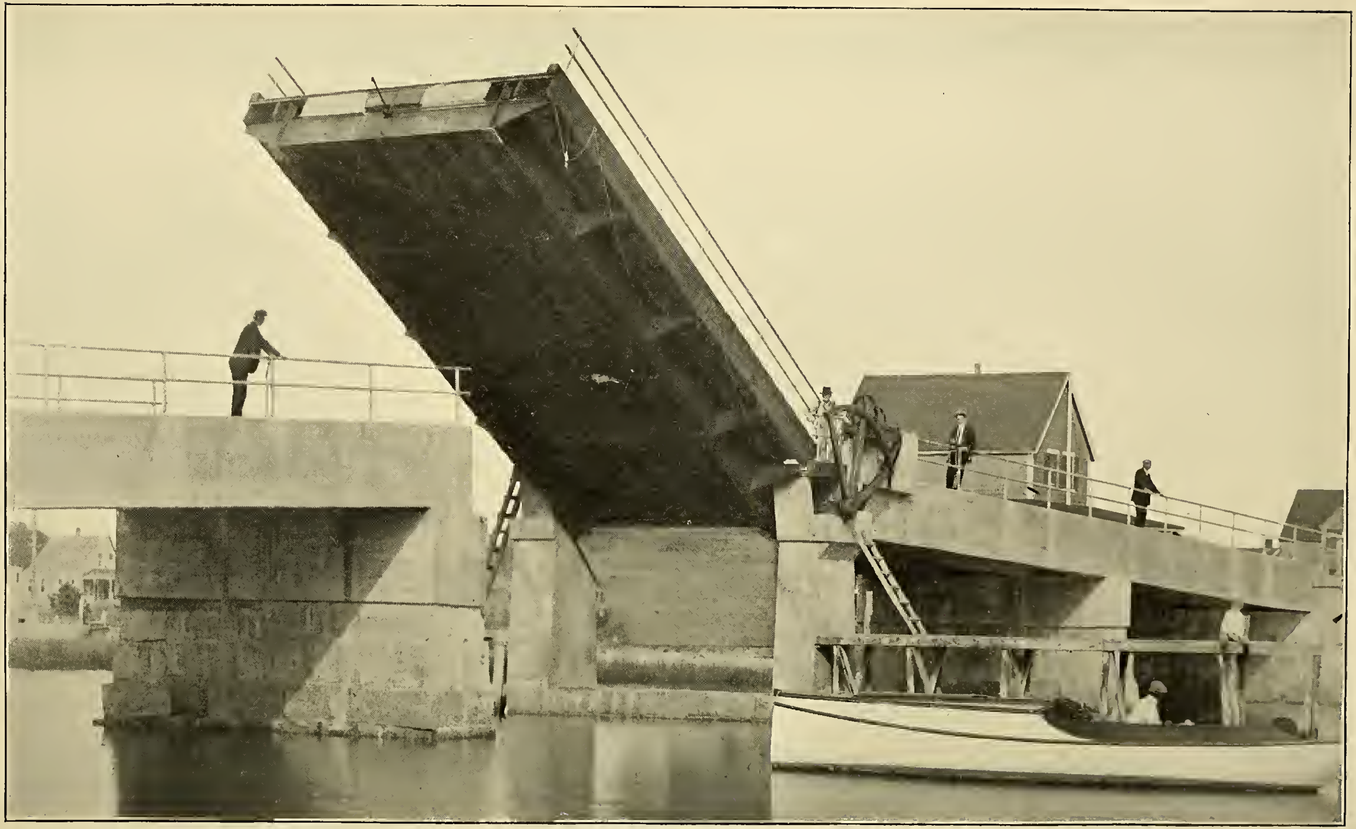


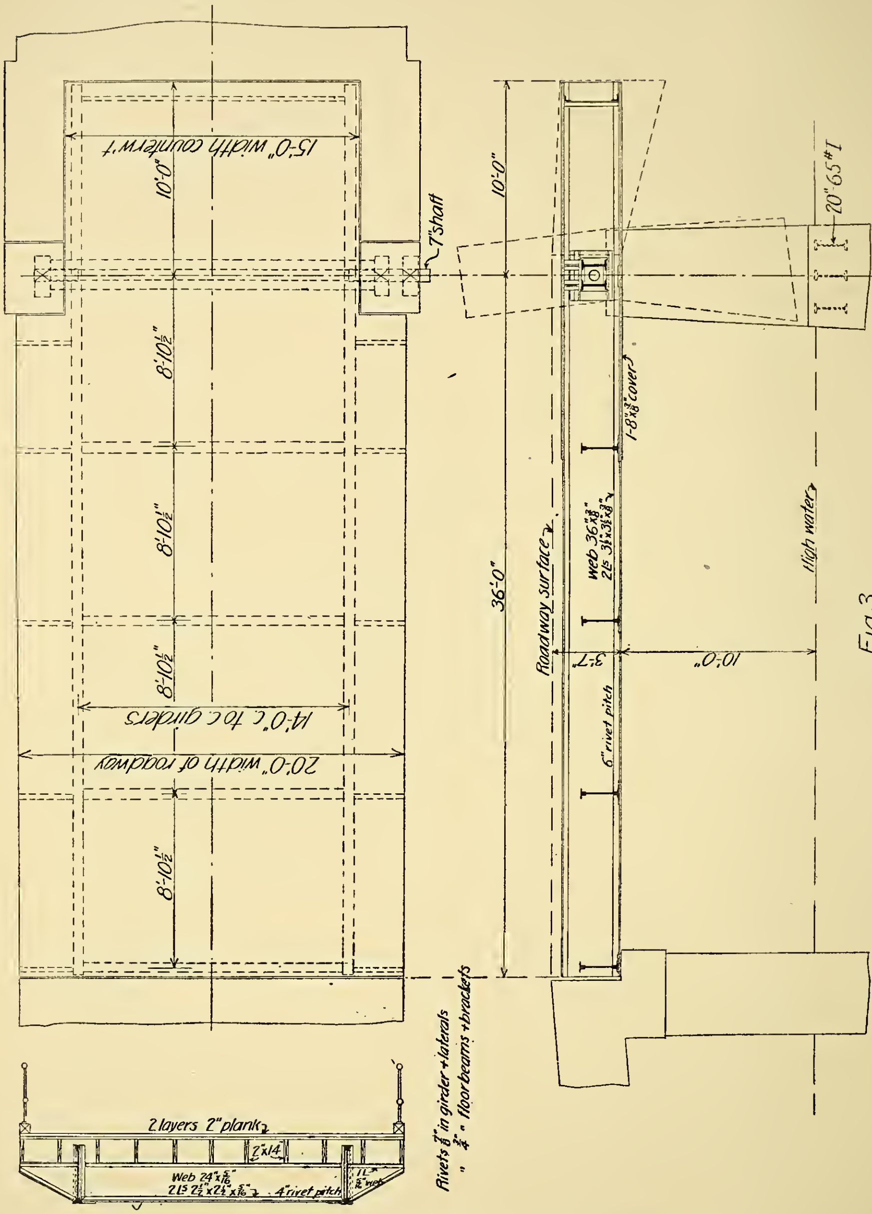
Fig. 2. Draw Span.

with a central draw span of about 38 ft. The contract plans showed a sketch of a double-leaf steel draw span similar in type to the wooden one which was part of the old bridge; having the usual gallows frames, windlasses and chains for raising the bridge.

Upon inquiry as to the method of operation, the writer found that the bridge was to be operated by hand in a manner similar to the former bridge. There being only one draw tender, he was obliged to raise one leaf of the draw, get into a boat, row across to the other side, and then raise the other leaf. As it was desired to operate by hand, the double leaf was at once eliminated from consideration because of the awkwardness of operation and because of greater first cost and greater cost of maintenance.

After making several trials of different combinations of girders, the writer settled upon the bridge as shown in Fig. 2. This view shows clearly the type of construction adopted, which consisted of two longitudinal girders having four floor beams with wooden stringers and a wooden floor of the ordinary type resting upon them. At the mainland end is an axle extending completely across the bridge, supported in bearings on the piers. The portion of this axle between the girders was made of two I-beams for the double purpose of cheapness and of having the I-beams act as the fifth floor beam. The whole structure is counterbalanced by a solid concrete counterweight, the upper surface of which forms part of the floor surface of the span adjacent to the draw. When completely opened, the counterweight swings downward into the space between the two concrete columns at the ends of the draw pier. The draw is opened and closed by the quadrant shown, which is keyed to the axle, and a train of gears.

Fig. 3 shows a plan, elevation and cross-section of the bridge. As will be seen, the floor is of the ordinary type of construction, having two layers of 2-in. planking on 2-in. by 14-in. hard pine stringers, spaced 2 ft. on centers. Holes were punched in the top flange of the floor beam and $\frac{3}{4}$-in. lag screws driven into the bottom of the stringers to hold them in position when the draw is open. The stringers abut against the counterweight at their right hand end, which relieves the floor beams from any bending in a direction perpendicular to the face of the web when the bridge is open, and also obviates expensive bracing of these beams. The outer bracket is held by a single hitch angle, and no provision is made for a plate connecting the top flange of the floor beam to the top



PLAN, ELEVATION AND CROSS-SECTION OF DRAW SPAN.

of this bracket. The tension upon the connecting rivets is relied upon to hold the bracket in place.

The writer is not in the least afraid to trust rivets which are driven with ordinary care in tension, as, under modern methods of handling and driving rivets, he believes a rivet to be fully as strong in tension as a bolt. Such tests as have come to the writer's notice bear out this belief.

Any tendency of the brackets to twist sideways is amply resisted by the wooden stringers, which are fastened to the bracket, and by the floor planking, which is continuous over the whole width of the roadway.

The composition of the girder is shown on the elevation. It will be noted that the girder is carried back nearly to the extreme end of the counterweight. As stated before, the upper surface of the counterweight forms part of the wearing surface of the adjacent fixed span. Except for the draw span itself, the wearing surface of the whole bridge is formed by the upper surface of the slabs and is concrete. When the bridge is opened, the counterweight drops, leaving an open well about 10 ft. long and 15 ft. wide in the surface of the adjacent fixed span. The outline of the floor is of the shape shown in the plan.

By considering the elevation and plan together, it will readily be seen that when the bridge is opened, the counterweight drops down and the bridge rises up. Owing to the configuration of the floor, as the bridge rises the flooring over the channel rises away from the flooring on the pier. The counterweight, as before stated, drops away from the floor surface of the adjacent span. The result of this is that the apron so commonly used on wooden bascule draws is entirely done away with, and the operator is only obliged to unlock the outer end of the bridge and turn a crank to open it. A portion of the flooring about 3 ft. wide by 4 ft. long over each end of the supporting axle is made removable to allow of ready access to the machinery at any time. The adoption of this type of construction necessitated the redesign of the span adjacent to the draw, making it U-shaped next to the draw pier. The upper surface of the concrete girder on one side is utilized as a space on which the draw tender stands when opening and closing the bridge, and forms part of the road way surface when the bridge is closed. It is offset, to permit the railing on the draw to swing past the railing on the fixed span.

The axle upon which the bridge turns is composed of two 15-in. 42-lb. I-beams, which extend through a rectangular hole

cut in each girder. An iron casting, or elongated separator, is used between the I-beams at each end and extends from a point just inside the web of the girder to the face of the bearing on the abutment. A 7-in. shaft is secured in this casting by means of keys and bolts and forms the journal upon which the bridge revolves. The shaft at one end is made just long enough to extend through one bearing and at the other end is extended through two bearings and has keyed to it at its outer end a gun-metal quadrant which is operated through a train of gears. The bearings are of phosphor bronze and babbitt. The phosphor bronze is used in the lower half of the two boxes closest to the girder. The babbitt is used in all the caps and the box next to the quadrant. The concrete counterweight is fan-shaped in elevation and completely envelopes the girders for the full length of the counterweight. The girders are tied together by angles at their right-hand ends, and a vertical stiffener is put on the inside of each girder in order to serve as an anchorage for the counterweight. The counterweight was computed as a reinforced concrete beam between the girders and was designed to carry the roadway loads in addition to its own weight. It is reinforced by $\frac{3}{4}$-in. bars spaced 12 in. on centers, laid on the bottom flanges of the girders. The lower edge is similarly reinforced, the bars in this case being hung on vertical rods bent over the top flanges of the girders. When the bridge is open, the counterweight and bridge occupy the position shown by the dotted lines. This made necessary a redesign of the pier supporting it. The design of the pier is best shown in Fig. 2.

The solid masonry pier is cut off horizontally at a point just above high water, and two stout concrete posts are carried up at each end. These concrete posts are approximately 2 ft. 6 in. by 3 ft. 6 in. each. The bearings for the support of the draw span rest on the top of these posts, as do the girders of the approach span. This figure also shows clearly the way in which the floor of the draw rises, and also shows the removable part of the flooring over the machinery. The sloping concrete bracket is for the purpose of carrying the outer edge of this removable section of floor. The piers on the bridge in general are constructed of split granite with a concrete cap. In order to prevent any possibility of the draw pier splitting, three 20-in. 65-lb. I-beams were laid on top of the top course of granite to distribute the weight of the bridge. In order to protect the concrete with which the I-beams are surrounded from the action of the salt water, a belt course of granite was laid around it and thoroughly

tied in by means of iron dogs. This course was laid first and used as the form for the concrete surrounding the I's.

As the upper surface of the counterweight forms part of the flooring of the approach span, any live load which comes upon it tends to make the outer end of the draw rise. This makes it necessary to lock the outer end down. It is also necessary that this locking be done in such a way that the end of the draw is held tightly to the abutment so that it cannot hammer as a load passes over it.

The mechanism for accomplishing this is shown in Fig. 4. It consists of an eccentric carrying an elongated hook. The hook is free to swing about the eccentric, being held against the end floor beam by a spring. When the bridge is nearly closed, this hook snaps over a suitable loop on the abutment and is then tightened up by revolving the eccentric by means of a lever and a rope extending to the place where the draw tender stands. The action of this eccentric is to raise the hook drawing the ends of the bridge tightly down on to the wall plates. When it is desired to open the bridge, the rope is pulled and the lever moves, lowering the eccentric and relaxing the tension on the hook. Just before the extreme motion of the lever is reached, the notched collar strikes a pin on the hook and moves it out clear of the loop. The bridge is then free to open. The hook is shown on Fig. 2, but not in its proper position, as this mechanism was never operated as it was designed so far as the automatic catching feature is concerned, probably because the speaker did not go down himself and give detailed instructions as to how it should be handled.

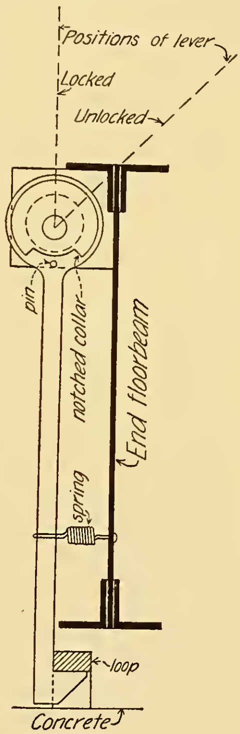


Fig. 4

LOCKING MECHANISM.

The steel work was fabricated and erected by the Guy Leavitt Company of Cambridge.

The cost of the structure as given below does not include the pier. The pier should be no more expensive than an ordinary full depth, full height pier.

The itemized cost to the contractor of the draw span is as follows:

Steel work and machinery, f. o. b. Boston	$945
Freight, erection and painting	625
Wooden floor	200
Concrete counterweight	225
Total	$1,995

or practically $2 000 for the draw span complete and ready for service.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1913, for publication in a subsequent number of the JOURNAL.]

ASPHALTIC CONCRETE AS A PAVING MATERIAL FOR RESIDENCE STREETS, SUBURBAN DISTRICTS AND BOULEVARDS.

By Linn White.

[Read before the Civil Engineers' Society of St. Paul, April 7, 1913.]

The ideal pavement for all conditions has not yet been produced and probably never will be.

What is the most *suitable* pavement is a problem that must be studied by the officials responsible for such matters with relation to kind of traffic, character of district served, probable future growth, limit of cost, conditions of soil and climate, grades, provisions for maintenance, etc. The streets of a heavily traveled business district require, first of all, a permanent surface on an unyielding foundation, and the question of cost properly receives but secondary consideration. It is regrettably true, too, that the important considerations of cleanliness and noise generally receive only secondary or later consideration.

On light traffic streets, or those of mixed service, permanency is hardly so imperative, and the consideration of cost becomes more important. Here, also, the future growth or probable change from a district partly occupied by residences to one devoted entirely to business should receive careful consideration.

A third general class of streets, comprising residence streets, boulevards and those serving suburban districts, is the class it is proposed to discuss in this paper. The general character of the districts served may be considered fairly well established, so no great changes in *kind* of traffic may be anticipated. The traffic on such streets is seldom what is probably termed "heavy," but may be "intense," that is, there may be a great many rapidly moving, comparatively light vehicles. Automobiles will predominate, with a lesser number of horse-drawn passenger vehicles. At times, heavy teaming of building material, produce, coal, etc., must be provided for, and the general delivery and express service for the district.

To satisfy the requirements of such cases, a pavement must have many high qualities, and the standard is all the time growing higher, the public exacting and expecting better service. It must be reasonably permanent, moderate and flexible in cost, serviceable on all kinds of foundations, sanitary, smooth, dust-

less, noiseless, non-slippery, resilient, and agreeable to the eye in strong sunlight. Quite a formidable list of virtues difficult to attain.

Examining the different generally known kinds of pavements we will at once pass up many of them as possessing in an eminent degree only a few of the qualities named. Brick, concrete, stone block and wood block all possess some of these qualities but are lacking in others. Macadam cannot be classed as a permanent pavement, and we are thus reduced to some form of bituminous paving surface.

Sheet asphalt (sand asphalt) pavement is the best known and most widely used form of bituminous pavement — at least, it has been so for years past, though now other forms are becoming extensively known. Sheet asphalt must, however, be made comparatively thick, say three inches, to conform to accepted standards; its cost is comparatively high, dependent on its thickness, though not in direct ratio thereto; it is suitable for use only on a concrete base; has a smooth, sheet-like surface more or less slippery; and last but not least has fallen somewhat into disrepute because of the skill and care required to produce a successful paving mixture and the constant effort during recent years to reduce its cost. Asphalt block is a pavement that has been in existence for many years, but has not come into general use because of its high cost and difficulty of manufacture and transportation.

Macadam surfaces bonded by the application of bitumen in a liquid form have come largely into use during recent years, but have not established themselves as a standard type of pavement because lacking in the very essential quality of permanency under considerable traffic. Their place is on the country highway and roads of occasional traffic.

Having thus briefly reviewed the principal varieties of street pavement known and used in this country, we come to the one remaining general variety, designated as " bituminous concrete." Under this general name is included all paving mixtures consisting of broken stone combined with sand or other fine mineral matter, cemented together by a bituminous binder, which may be either tar or asphalt, making either " tar concrete " or " asphaltic concrete."

While both tar and asphalt are hydrocarbon compounds, their qualities are quite different. Tar, for practical use in a pavement, cannot have a melting point much higher than 130 degrees fahr., as it would become very hard and brittle in cold

weather. In this climate it is not unusual to find temperatures of 115 or even 120 degrees fahr. on the street surface, under which conditions a tar binder melting at less than 130 degrees would be almost liquid and have but little cementing or bonding value. In other words, tar, while quite adhesive and ductile, is very susceptible to changes of temperature. For these reasons it will not be considered further in this discussion.

The various asphalts that may be used in an asphaltic concrete have very different qualities and require different treatment, which will be briefly alluded to later.

For a paving mixture to merit the name of asphaltic concrete, the broken stone, according to a definition adopted by the American Society of Municipal Engineers, must be in sufficient quantity to form an important part of the mixture; also the ingredients must be combined and mixed before being laid. Neither the size of the stone nor the proportion of the various sizes in the mixture can be limited by the name "asphaltic concrete," any more than the size and proportions in a hydraulic concrete can be limited by the name. This can be done only by the specification of the particular mixture it is desired to produce.

Several varieties of asphaltic concrete are offered on the market under trade names, copyrighted or patented, that presumably conceal or but half reveal their somewhat mysterious qualities, such as Bitulithic, Amiesite, Filbertine, Warrenite, Westrumite, etc. They are all asphaltic concretes founded on the old concrete idea of a broken stone aggregate supported and held together by a mortar matrix.

The first one named, Bitulithic, is supported by letters patent in which the principle of filling the voids in the aggregate by the use of successively smaller sizes down to impalpable powder is exploited. It is claimed by this method of grading the sizes of the mineral that an "inherent stability" is produced in the pavement independent of the asphaltic binder, which then may be very soft and serve only to waterproof the mixture and to fill the remaining small percentage of voids. Several patents have been issued to the originators of this pavement, the claims of which to the lay mind seem very similar, all of which rely upon this main idea of carefully grading the aggregate, and some of which describe carefully the process of separating the mineral into a number of sizes and recombining them according to a definite formula. This brings out the idea of "predetermining the sizes" of the mineral aggregate, which is a phrase met with in Bitulithic literature.

There is another claim in the Bithulithic patents that is an excellent one if carried out to its logical conclusion, that is, that by reason of filling voids so completely by grading the mineral the quantity of asphaltic binder may be reduced and the pavement "produced at a smaller cost." This is a quotation from the claims of the patent, and if *produced* at a smaller cost it naturally should be sold at a smaller cost, thus justifying protection under the patent laws and earning the gratitude of the nation.

These references are made to the claims of the Bitulithic pavement disregarding the other special asphaltic concrete pavements named above because the Bitulithic is the only one that endeavors so to broaden its claims as to monopolize the field of asphaltic concrete paving. If we sum up the claims of the Bitulithic patents, we find they hinge upon, and in fact are reiterations of, the principle of reducing voids by carefully graded sizes so that an "inherent stability" is produced and less bitumen used, thus reducing cost and increasing usefulness.

If it is true that Bitulithic methods are the best and cheapest, it becomes the duty of every engineer and city official to support them and use them. Let us examine the situation a little further and see what conclusions can be drawn on this point.

It cannot be contended that good Bitulithic pavements *are* not produced, for many excellent examples may be found throughout the country. At the same time many excellent examples may be found of sheet asphalt pavements, and it cannot be contended there is any "inherent stability" in the sand of which they are composed. All the stability must be supplied by the asphaltic cement.

In 1907 a contract was let to the Bitulithic Company for about three miles of pavement on Michigan Avenue and South Park Avenue in Chicago, which was laid during 1907 and 1908. On these avenues there is but little heavy teaming, as they are boulevards and under usual boulevard restrictions as to traffic. In 1908 a traffic census showed from 3 000 to 5 000 vehicles per twenty-four hours on the three miles of pavement in question, which by 1912 had increased to from 5 000 to 12 000 per twenty-four hours, — practically doubling the average number.

During the summer of 1909 some small portions of the surface began to show a tendency to form waves and ruts, but was scarcely noticed, being considered only local or accidental defects. It was not thought there could be anything very serious the matter; the spell of "inherent stability" was too strong.

By the summer of 1910 conditions were much worse, and the contractors put heavy rollers on to smooth out the waves and ruts, also attempting to roll into the surface, first, limestone screenings, then granite chips, and, finally, crushed granite about three quarters of an inch in size. These expedients one by one failed. The screenings, chips and crushed granite could not be forced very deeply into the surface and most of the particles were easily loosened and torn out again by the traffic. It was found that while the rollers smoothed out the surface it wouldn't stay smooth, but quickly formed ruts again as long as warm weather continued. By keeping the rollers going more or less all the time until cooler weather arrived, the streets were kept in fair condition for the winter, but early in the summer of 1911 the campaign had to be begun again.

This season it was prosecuted more vigorously. The crushed granite was coated with bitumen to make it bond more effectually into the body of the pavement.

The surface of the street was punctured full of small holes into which the coated stone was swept and then rolled. These efforts were all of doubtful and temporary value. Conditions all the time grew worse, and it is safe to estimate fully $20 000, or from 25 to 30 cents per square yard, was expended by the contractors during the three seasons named without materially improving the condition of the pavement.

In the summer of 1912, under strong pressure from the Park Board, they abandoned their efforts to stiffen up the pavement and resurfaced the whole area with a layer of new asphaltic concrete about 1½ in. thick. The method followed was to go over it with surface heaters, softening up the surface until about an inch in thickness could be removed with rakes. Then the new 1½ in. layer of asphaltic concrete was spread and rolled, thus making it about ½ in. thicker than formerly. After this resurfacing the pavement was left in excellent condition at the end of the season of 1912 and so remains up to the present time.

It is to be noted the original pavement was specified to be at least 2 in. thick and actually averaged 2½ in. throughout a large portion of it; also that the original binder was tar. Thus the pavement is now composed of 1 to 1½ in. of tar concrete, overlaid with 1½ in. of asphaltic concrete.

In extenuation of the troubles on this particular pavement it may be pointed out that there are many excellent examples of Bitulithic pavement to be found. This is true. There is one other piece of Bitulithic pavement in Chicago, about one-half

mile long, on Sheridan Road, which is as fine a piece of pavement as can be found, and it is older than the Michigan Avenue pavement. But it is from one failure like this that we can learn more than from numerous successes that teach nothing.

It may also be argued that the traffic on Michigan Avenue was extremely severe, or that if the original binder had been asphalt instead of tar the result would have been better.

This may be true, but it is not to the point. The main point is the very important "inherent stability" was not in the pavement to resist displacement independent of the support of the binder; and if it was there at all it was not sufficiently "inherent" to resist the severe traffic.

The traffic, while severe, was not prohibitive, — was not sufficient to strain a good asphaltic concrete pavement beyond a safe limit. It was merely a severe test and developed a weakness that might have developed to a lesser degree or more slowly under lighter traffic.

In 1909 an asphaltic concrete pavement was laid on Michigan Avenue, between Twelfth Street and Jackson Street, which in 1911 was carrying a traffic of 17 000 vehicles during twenty-four hours. This was not laid by the Bitulithic Company nor under their specifications, and was the subject of a suit between the Bitulithic Company and the South Park Commissioners, of which more will be said later. No trouble has occurred with this pavement up to date except a comparatively small number of cracks which have in every case been traced to the concrete base. In explanation it should be said the street between these points is 75 and 85 ft. wide between curbs, having been widened 35 ft. to the eastward when paved in 1909. Thus a portion of the subfoundation is new filled ground and a portion the old street, and the support is uneven. Also the construction of a number of large buildings on the west side of the street has caused settlement in places and consequent cracks in the pavement.

This pavement is between the Bitulithic pavement and the center of the city and carries a larger traffic.

There were also asphaltic concrete pavements laid adjoining the Bitulithic on Michigan Avenue at 39th Street, and on South Park Avenue at 35th Street. They are on both avenues extensions of the bitulithic to the southward and carry the same traffic in slightly decreasing numbers. No trouble has occurred with these pavements and they have cost nothing for repairs up to date except on two intersections where the cross traffic was quite severe and has occasioned minor repairs.

As stated above, neither Bitulithic methods nor formulas were followed. No special care was taken to grade the aggregate except to be sure there was plenty of mortar to fill voids and the fine material in the mortar was in proper proportions to give a well-filled mixture. Beyond this the success of the pavement depended on the proper preparation of the base and the use of a suitable asphaltic binder. Dependence was had on only common-sense methods to resist lateral displacement, and the paving mixture was intended to be waterproof for obvious reasons. The heating and mixing were done in portable plants working on the street; the proportioning of the mineral ingredients was by wheelbarrow loads; and the prepared material was delivered quickly and directly on the street surface. Much of the success and moderate cost were doubtless due to the methods and machinery used. There was no overheating or chilling of material due to long hauls, no separation of ingredients from the same cause, and no bad work on account of delays either at the plant or on the street. The concentration of all operations in one place, under one superintendent, undoubtedly tended to better results in many ways.

The comparison of cost between the three sections of pavement referred to above is as follows:

The Bitulithic by contract cost $1.90 per sq. yd., exclusive of cost of base.

Asphaltic concrete by contract on Michigan Avenue, between 12th and Jackson streets, $1.73 per sq. yd., including concrete base, which would make it exclusive of base about $1.10 per sq. yd.

Asphaltic concrete laid by day labor on Michigan Avenue, south of 39th Street, and on South Park Avenue, south of 35th Street, less than 75 cents per sq. yd., exclusive of base.

Following are the analyses of the *mortar* constituent (that is, 10-mesh material or less) of several samples of asphaltic concrete which have been under traffic for long enough periods of time to demonstrate their good or bad qualities. The first four proved to be very good, and the latter two indifferent in quality.

	No. 1. Jackson and La Salle.	No. 2. Jackson and Main.	No. 3. Michigan and Park.	No. 4. Grand and Okwd.	No. 5. Jackson and Franklin.	No. 6. Jackson and Market.
	%	%	%	%	%	%
Bitumen	18.8	18.9	16.1	21.0	18.9	16.3
200-mesh	10.8	11.6	11.7	10.9	4.3	3.5
80- „	10.6	11.5	7.0	26.2	5.9	5.7
40- „	36.8	35.3	22.7	19.3	50.3	54.1
10- „	23.0	22.7	42.5	22.6	20.6	20.4
	100.0	100.0	100.0	100.0	100.0	100.0

As far as the coarse aggregate is concerned, that is, all material coarser than 10-mesh, there were considerable variations in the different samples, but the total quantity was approximately the same, and the variations seemed to have nothing to do with the success or failure of the sample. Samples 1 to 4 were successful, and they were rich in dust and reasonably well proportioned in other sizes up to 10-mesh. Samples 5 and 6 were practically failures, and they are seen to be lean in dust with an excess of 40-mesh material not well filled by the smaller sizes.

Here is where stability is found, or such "inherent stability" as belongs to the mineral aggregate of asphaltic concrete, not in the careful grading of the larger sizes. It would not matter if there was 25 or 50 per cent. of mineral larger than that passing a 10-mesh screen added to the mortars of samples 1 to 5; the result would have been the same. Nor would it matter if this 25 or 50 per cent. of coarse mineral was all of one exact size or of several carefully graded sizes; the pavement would have been good. Therefore, in the making of good asphaltic concrete, it is an axiom that we must have a good mortar, well proportioned as to mineral, with a good asphaltic cement to bond it properly together. Having this, the coarse aggregate may be added with considerable freedom. There are, of course, certain precautions that must be taken and certain useful refinements that may be attained, as in the making of other bituminous pavements. For instance, too much dust in a mixture will require more asphalt, etc. All such points could not be covered in such a discussion as this, but the principles stated above may be taken as fundamental.

There are on the market two general classes of asphalt binders, or asphaltic cements, as they are more properly called

when of a character suitable for use in paving mixtures, distinguished generally from each other by the presence or absence of any considerable degree of ductility. Ductility is the quality that enables a substance to be drawn out like chewing gum without breaking. It is of no direct value in the paving industry, but is supposed to indicate other qualities of value, such as cohesion and adhesion. At the same time it indicates other objectionable qualities, such as susceptibility to changes of temperature. A considerable degree of ductility is required in most sheet asphalt specifications, but engineers conversant with the most successful practice in asphaltic concrete work agree ductility is not an essential quality.

It may be conservatively said that good work can be done with either ductile or non-ductile asphalt, with simplicity of manipulation somewhat in favor of the non-ductile material.

These statements, however, are not intended to dispose of the question of which is the most durable under heavy traffic or to suggest that one class be chosen in all cases to the exclusion of the other.

Successful foundations may be made of either concrete or macadam. Where traffic is comparatively heavy, unquestionably the concrete base has the advantage of greater rigidity, more "inherent stability." On the other hand, macadam in some cases may be the more advantageous to use. It does not have to stand so long to set up before you can apply the wearing surface, consequently the street is not out of service so long, and if you are working over an old street, where there is some old macadam in a more or less worn-out condition, frequently considerable economy can be effected by using a macadam base. This is a question for the engineer to work out in each case.

One principle may be laid down to apply to either concrete or macadam base. Don't finish it up smooth, but leave the surface rough and grainy, so the paving material may be forced into the interstices.

The specifications promulgated by the Association for Standardizing Paving Specifications go into the question of preparing the base pretty well.

Some litigation was had in Chicago with the Bitulithic Company, of which the following is a brief statement.

In 1909, when the South Park Commissioners let a contract for paving Michigan Avenue from 12th to Jackson streets with asphaltic concrete, the Bitulithic Company sought an injunction in the federal circuit court. The injunction was denied by one

judge, but under some legal technicality the case was reopened before another federal judge in the same circuit. Injunction was again denied, and as this left the case before the court in such a shape that any further action would have to be a trial on its merits, the complainants dismissed the complaint and no attempt has been made since to renew it. To reach this partial conclusion in the courts required over a year, and of course before then the contract over which the litigation started was completed and the pavement in use. The South Park Commissioners, however, had proceeded to lay other considerable quantities of similar pavement and if good grounds for an injunction had been shown the result would have been to force them to come to terms with the Bitulithic Company, and account for royalties on both past and future work.

Up to date, considerably over one million yards of asphaltic concrete pavement has been laid in Chicago and the royalties would amount to a considerable sum.

It is unfortunate the Chicago case could not have been fought to a conclusion on its merits, as this might have made it possible to secure a Supreme Court decision on the Bitulithic patents and determine just what of their claims are valid. Several other decisions have been rendered in litigation of this patent, which are more or less conflicting, some in their favor and others contrary. It has been the policy of the patentees not to push any case to a conclusion where the preliminary rounds have been against them. For this reason it has been impossible to get an appeal into the Supreme Court.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1913, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

Ebenezer Smith Wheeler.

MEMBER OF THE DETROIT ENGINEERING SOCIETY.

BORN AUGUST 27, 1839.
DIED JANUARY 5, 1913.

In the recent death of Mr. E. S. Wheeler the Detroit Engineering Society has lost one of its most honored and beloved members, and one whose ability the Society has been pleased to recognize by conferring upon him its highest offices.

Mr. Wheeler was born in Wayne County, Pennsylvania, August 27, 1839. When he was five years old his family moved to Noble County, Indiana, where he received his early education. He entered the University of Michigan with the class of 1867, graduating with the degree of civil engineer. Previous to and for fifteen years following his graduation, Mr. Wheeler was engaged on the survey of the Great Lakes, attaining a very responsible position in this most important work. The methods he devised in connection with this work intrusted to him have since been recognized as standards in precise geodetic work throughout the United States and in foreign countries. When the Lake Survey temporarily suspended operations, in 1882, Mr. Wheeler was appointed resident engineer at Sault Ste. Marie, and was given immediate charge of all government work in that vicinity under direction of the district officer of the Corps of Engineers. Here he had charge of the construction of the Poe Lock, the widening and deepening of St. Mary's Falls Canal, the Hay Lake Channel, the 20–21 ft. channel through St. Mary's River, and many other smaller projects. When the question of the Nicaraguan Canal was being considered in 1897, Mr. Wheeler was logically chosen to take charge of the preliminary surveys and report on the project. He took immediate charge of all field operations and made a very complete analysis of the data, and in 1898 submitted a very complete and detailed report to the Nicaraguan Canal Commission. The report clearly proved that the undertaking was entirely feasible and it would undoubtedly have been the basis for the construction of the Inter-Oceanic Canal if the project had not been abandoned on account of favorable developments in connection with the alternative plans at Panama.

In recognition of Mr. Wheeler's ability and attainments in the engineering profession, the University of Michigan in 1897 conferred upon him the honorary degree of master of science.

After concluding his work with the Nicaraguan Canal Commission, in 1898, he returned to Detroit to assume the duties of principal assistant engineer in the United States Engineer Office, occupying this position until his death. In this capacity he rendered invaluable service, in an advisory way, on many important works in this district. He also had immediate charge of the new canal at the St. Clair Flats and the breakwater at Mackinac Island. As a result of Mr. Wheeler's connection with work on the Lakes, he became deeply interested in the study of lake levels, run-off and other matter connected with hydrology, and the results of his observations and studies have added greatly to the knowledge of the subject.

It was during this time that Mr. Wheeler conceived the idea of an instrument which would automatically indicate to the master of a vessel the presence of shoal water. This instrument, which is commonly known as the Wheeler Bathometer, is fast winning recognition on the Great Lakes and is destined to become a safeguard against the loss of life and property. This instrument was demonstrated before the Society both on the occasion of a monthly meeting and also on one of the annual excursions.

Mr. Wheeler's connection with the Detroit Engineering Society began in 1900. In 1906 he was elected Second Vice-President and the following year was made President.

Notwithstanding Mr. Wheeler's many gifts and his achievements as an engineer, he was exceptionally companionable, always looked on the bright side and had a keen sense of humor, being always ready to lighten the labor of the day by a good joke or an appropriate story. In disposition he was modest and retiring, but even on short acquaintance one was impressed with his broad character and exceptionable ability.

Mr. Wheeler was a member of the American Society of Civil Engineers, Michigan Engineering Society, Detroit Engineering Society, University Club of Detroit, and was a member of several Masonic bodies.

Mr. Wheeler married Miss Clara P. Fuller in 1874, who, with one daughter and one son, survives him.

In the death of Mr. Wheeler the Detroit Engineering Society has lost one of its most distinguished members, and this

loss is keenly felt by all who have had the privilege of knowing him.

The Detroit Engineering Society, assembled at its nineteenth annual meeting, deplores Mr. Wheeler's death and extends to his family its sincere sympathy.

E. J. Burdick, *President.*
Frederick H. Mason, *Secretary.*

Albert Safford Cheever.

Member of the Boston Society of Civil Engineers.

Albert Safford Cheever, son of Tracy P. and Louisa (Kilburn) Cheever, was born in Chelsea, Mass., on September 17, 1857. He was educated in the public schools of Chelsea and entered the employ of the Fitchburg Railroad Company in the office of the general superintendent in 1880. Soon after, he was transferred to the engineering department and until the latter part of 1886 was located at Fitchburg, Mass. In that year the Troy & Greenfield, the Troy & Boston and the Boston, Hoosac Tunnel & Western railroads were acquired by the Fitchburg and Mr. Cheever was appointed division engineer at North Adams, in charge of the rebuilding and maintenance of those roads. In 1891, upon the retirement of Mr. E. K. Turner, he was appointed chief engineer, and returned to Fitchburg, remaining there until August 30, 1897; when he resigned to engage in manufacturing in Cleveland, Ohio. In about a year he returned to the Fitchburg Railroad as assistant to the president, and was soon after reappointed chief engineer, remaining in that position till the Fitchburg was leased by the Boston & Maine Railroad, July 1, 1900; he was then made assistant chief engineer of the latter road.

On November 1, 1902, he was appointed superintendent of the Fitchburg Division, which position he occupied till November 15, 1912, when he was made assistant to the vice-president in charge of operation.

Since about 1884, Mr. Cheever has been a member of the Aurora Lodge of Masons of Fitchburg.

On Sunday, February 16, 1913, he suffered an attack of acute indigestion, from which he died the following morning at his home, No. 6 Aldersey Street, Somerville, Mass.

Mr. Cheever was married at Fitchburg, on June 7, 1893, to Josephine M., daughter of John J. and Mary (Brown) Grant,

who with two children, a son, Walter G., and a daughter, Alice, survives him.

Mr. Cheever was essentially an all-around railroad man, with preference for the constructive engineering side. He was always attentive to his duties in whatever direction they might lie and was popular with subordinates and superiors alike. While he exacted good work from contractors, he dealt fairly with them and was very successful in handling construction work. He was an honorable man with a keen sense of humor, and a genial companion, and his loss is keenly felt by all who knew him.

Mr. Cheever was elected a member of the Boston Society of Civil Engineers on January 23, 1895.

J. P. Snow,
H. W. Hayes,
Committee.

Association of Engineering Societies.

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PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., October 16, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair.

The reading of th record of the last meeting was dispensed with and it was approved as printed in the October *Bulletin.*

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Messrs. John A. Guiney, Herbert Daniel Hurley, Arndt Thomas Iverson, Austin Louis Maddox, Percival Hildreth Mosher, Arthur Edwin O'Neil, Anthony Winfred Peters, Lawrence Minot Pitman, Charles Franklin Powers, George Hermon Stearns, George Hilton Thorpe.

Juniors — Messrs. Benjamin Boas, William Haskins Coburn and Beardsley Lawrence.

The President stated that the business before the meeting was to act on the following vote which was passed at the last meeting of the Society.

" *Voted:* That a sum not exceeding $2,000 be appropriated from the Permanent Fund of the Society to be expended under the direction of the Board of Government for furnishing and fitting up the Society's rooms."

Mr. Howe spoke in opposition to any appropriation from the Permanent Fund and suggested that the money be loaned from that fund, to be paid back from the Current Fund later. He read a statement giving the history of the fund and showing that this method had been used on former occasions.

At the conclusion of Mr. Howe's statement, on motion of Mr. Hodgdon it was voted that this meeting adjourn to the third Wednesday in November at 7.30 o'clock P.M.

The meeting was then turned over to the American Society of Mechanical Engineers, Prof. E. F. Miller in the chair.

The principal feature of the meeting was a description of the water power development of the Mississippi River Power Company at Keokuk, Ia., by Mr. Hugh L. Cooper, chief engineer of that company. By way of introduction Mr. Cooper showed a few slides illustrating some very ancient and primi-

tive applications of water power, also some notable features of other undertakings in which he had been interested, followed by a large number of slides showing the immense undertaking at Keokuk and its several parts in various stages of progress, all of which was described and commented on in a most entertaining and instructive manner.

Next Mr. D. L. Galusha, engineer with Stone & Webster Engineering Corporation, presented a brief illustrated description of the main electrical features of the plant, including the generators, switching and other powerhouse equipment, and transmission line construction.

The many interesting features of this work were further brought out by the questioning and general discussion which followed, and which was participated in by several members of the various Societies.

The attendance was about 425.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., NOVEMBER 20, 1912. — In pursuance of a vote of the Society passed at its regular meeting, October 16, 1912, an adjournment of that meeting was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.30 o'clock by the President, Mr. James W. Rollins.

The President stated that the matter under discussion at the time of adjournment was the following vote which had been passed at the September meeting of the Society:

> " *Voted:* That a sum not exceeding $2,000 be appropriated from the Permanent Fund of the Society to be expended under the direction of the Board of Government for furnishing and fitting up the Society's rooms."

Mr. FitzGerald moved, and it was duly seconded, that action on the vote be indefinitely postponed.

After a prolonged discussion, during latter part of which Vice-President Fay occupied the chair, the motion to indefinitely postpone was lost, 8 in favor and 35 against.

The vote passed at the September meeting, namely: That a sum not exceeding $2,000 be appropriated from the Permanent Fund of the Society to be expended under the direction of the Board of Government for furnishing and fitting up the Society's rooms was then passed for the second time, in accordance with the Constitution of the Society, 58 voting in favor and 8 against.

At 8.45 o'clock the meeting adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., NOVEMBER 20, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8.45 o'clock, President James W. Rollins in the chair, 98 members and visitors present.

The reading of the record of the last meeting was postponed until the next meeting.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

As Members — Messrs. Clarence M. Brooks, Albert Joseph Holmes, John Henry McCormick, Jr., Edward Frederick Olson, James Jarvis Preble, Leonard Ernest Schlemm and Edward Richard Smith.

As a Junior — Mr. Philip James Doherty.

It was voted to postpone until the next meeting the consideration of the report of the Committee on Code of Ethics.

Past President Frank W. Hodgdon was then presented and gave a very interesting talk, illustrated by lantern slides, entitled "Some Incidents of Survey of Mountains near the Boundary between Costa Rica and Panama."

S. E. Tinkham, *Secretary*.

Meetings of the Sanitary Section.

Boston, Mass., November 27, 1912. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at the Society rooms in Tremont Temple. Chairman George C. Whipple called the meeting to order at eight o'clock, and introduced the speaker of the evening, Mr. Langdon Pearse, division engineer of the Sanitary District of Chicago. Mr. Pearse gave a very interesting and valuable description of "The Sanitary Work of the Sanitary District of Chicago," paying particular attention to the experiments made and the results obtained by the sewage testing station. Lantern slides were used to illustrate the talk. Many diagrams were shown to illustrate the changes in chemical constituents in the water of the drainage canal and the degree of purification effected by the various sewage treatment methods.

The subject was discussed by Messrs. Geo. C. Whipple, Charles Saville, H. P. Eddy and others. In view of the fact that it was the night before Thanksgiving Day, the attendance, 47, must be considered a very good showing. The meeting adjourned at 9.45 o'clock P.M.

Frank A. Marston, *Clerk*.

Boston, Mass., December 4, 1912.— The regular December meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at the Boston City Club. Dinner was served shortly after 6 o'clock to 17 members and guests. At 7.30 o'clock the meeting was called to order by Chairman George C. Whipple. As no objections were offered, the minutes of the two last meetings were declared approved as printed in the *Bulletin*. The Chairman announced the death of Mr. George A. Kimball and spoke briefly of the personal loss felt by the members as well as the loss to the Society. Mr. Kimball was always deeply interested in the work of the Section and was a regular attendant of the meetings.

The speaker of the evening was Dr. Rudolph Hering, consulting sanitary engineer of the firm of Hering & Gregory, of New York City. Dr. Hering spoke on "Refuse Disposal," using lantern slides to illustrate his talk.

Dr. Hering stated that in considering what method to use in the disposal of a city's refuse, the cost of collection was a very important feature, and many times it was the controlling feature in deciding between the reduction process and incineration. The refuse should be treated, first, so as not to spread disease; second, so as not to produce a nuisance; and third, in the most economical manner.

The discussion at the close of the talk was entered into by a number of the members. A vote of thanks was extended to Dr. Hering for his courtesy in bringing so many interesting and valuable facts before the Section. The meeting adjourned at 9.45 o'clock. The attendance was 47.

Frank A. Marston, *Clerk*.

Boston, Mass., December 18, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair, 92 members and visitors present, including ladies.

The reading of the records of the October and November meetings was dispensed with, and they were approved as printed in the *Bulletins* for November and December.

The consideration of the revised report of the Committee on Code of Ethics was taken up, and after a short discussion by Prof. F. B. Sanborn, the code was adopted as printed in the November *Bulletin*. The revised report is as follows:

The code is intended to establish certain general principles and rules of action for the members of the Society.

I.

Engineers should encourage sound engineering learning and training in the scientific schools and in actual work.

II.

The success of engineers depends upon their moral character, scientific attainments, industry, integrity and business talent. Aggressive competition which often prevails in ordinary commercial transactions cannot exist among engineers without diminishing their usefulness and lowering the dignity and standing of the profession.

III.

The first duty of engineers is to their clients or employers, who have a right to expect that the portion of their business entrusted to the engineer will receive careful investigation and intelligent treatment, and that any special information derived by the engineer during his employment, will be considered confidential.

IV.

Engineers in their professional relations should be governed by strict rules of honor and courtesy. Their conduct toward each other should be such as to secure mutual confidence and good will.

(*a*) They should take no step with a view to divert to themselves the clients or work of other engineers.

(*b*) If a client should desire to transfer his work to another engineer, it is his privilege to do so, but the engineer in charge should be given notice, with the reason for the same, of such change by the client, and the engineer to whom it is transferred should, before accepting the work, communicate with the engineer in charge, in order that there may be no bad feeling caused through misunderstanding.

(*c*) All communications should be made through a responsible head, unless another has been designated to act for him.

(*d*) Services of an assistant to an engineer should not be secured without first communicating with the principal to ascertain if such action will interfere with his work.

(*e*) An assistant should not accept employment with another engineer without first consulting his superior.

(*f*) A superior should not stand in the way of advancement of a subordinate.

(*g*) The criticism of another's work should be broad and generous. The success of one member brings credit to the profession, and the failure of one, discredit to the whole.

(*h*) The attitude of superiors to subordinates should be that of helpfulness and encouragement.

The attitude of subordinates to superiors should be one of loyalty, free from captious criticism.

The treatment of each by the other should be open and frank.

(*i*) The engineer should be willing to assume his proper share of public work and render such assistance as is possible for the general good of the community.

V.

Consultations should be encouraged in cases of doubt or unusual reponsibility. The aim should be to give the client the advantage of collective skill. Discussions should be confidential. Consulting engineers should not say or do anything to impair the confidence in the regular engineer, unless it is apparent that he is wholly incompetent.

VI.

With the understanding and consent of their clients, engineers may beforehand place any value on their services deemed proper.

Fees may be made upon a per diem, monthly or yearly basis, or as a fixed sum or upon a percentage basis. In addition a retainer may be charged.

It is desirable that a definite agreement be made in advance as to the fee and the extent of the work to be done, so as to avoid subsequent misunderstanding. The period of time should be designated during which the agreed fees shall apply and beyond which an additional or modified charge may be made.

VII.

Engineers should promptly inform their clients of any business connections, interests or circumstances which might prevent them from giving an unprejudiced opinion.

They should not receive commissions or any remuneration other than their direct charges for services rendered their clients.

In advertising, they should avoid, as far as possible, commercial methods.

VIII.

Engineers acting as experts in legal and other cases, in making reports and testifying, should not depart from the true statement of results based on sound engineering principles. To base reports or testimony upon theories not so founded and thereby produce erroneous results, is highly unprofessional and brings discredit on the profession, and upon the engineers guilty of such conduct.

IX.

The attitude of engineers toward contractors should be one of helpful coöperation and tactfulness, combined with just and firm criticism. They should assume a judicial attitude toward both parties to the contract.

X.

As the lines of distinction between the various branches of engineering are becoming less marked, an intimate relation between them should be encouraged.

Charles T. Main,
Frederic P. Stearns,
George B. Francis,
Charles R. Gow,
Charles B. Breed,
Committee.

The President announced the deaths of the following members of the Society:

Theodore O. Barnard, died October 20, 1912.

George A. Kimball, died December 3, 1912.

Charles A. Allen, died December 7, 1912.

By vote the President was requested to appoint committees to prepare memoirs of the deceased members named. The committees appointed are as follows:

On memoir of George A. Kimball, Messrs. J. R. Worcester, J. W. Rollins and C. T. Fernald.

On memoir of Charles A. Allen, Messrs. William Wheeler and H. P. Eddy.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grade of Members — Messrs. Leslie Burton Ellis, John Stacey Humphrey, Harry Rogers Sprague, Joseph Alloysius Rourke, Arthur Stillman Tuttle, Albert Olof Wilson and Bernard Blyth Wones.

The President then introduced Mr. George A. Harwood, chief engineer, Electric Zone Improvement, New York Central & Hudson River Railroad, who read a paper entitled, " The Construction of the New Grand Central Terminal for the New York Central & Hudson River Railroad Company." The paper was illustrated by lantern slides and was listened to with marked attention.

At its conclusion, on motion of Mr. Fay, the thanks of the Society were unanimously voted to Mr. Harwood for his very interesting and instructive paper.

Adjourned.

S. E. TINKHAM, *Secretary.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., DECEMBER 9, 1912. — The regular meeting of the Civil Engineers' Society of St. Paul was held in the House Chamber of the Old Capitol, December 9, 1912; present, 26 members and about 15 visitors.

The business meeting was deferred until after the lecture given by Mr. Walter Buehler, of the Kettle River Quarries Company of Minneapolis, on the subject of the " Methods of Applying Cresote to Timber " as practised at the above-named company's plant at Madison, Ill.

Mr. Buehler explained at some length the methods of handling paving blocks, ties, piles, bridge timbers, etc., before and after treatment at the Madison plant, also the capacity of different woods of varying degrees of porosity for absorbing preservative oils. He laid considerable emphasis upon the desirability of specifying a maximum as well as a minimum density for paving oils, and cited instances to show where too heavy oils had subsequently exuded from paving blocks, causing considerable annoyance to merchants and householders on account of being tracked into places of business and residences. His lecture was illustrated with stereopticon views of the plant at Madison, and pavements in process of construction in different parts of the United States.

Special features of the creosoting process were brought out by questions by several of the members, and the lecture closed about 9.45, all feeling that a profitable evening had been spent.

The business meeting followed. After the approval of the minutes of the November meeting, Mr. Annan, for the committee appointed to examine Article 3 of the Society's Constitution with regard to the eligibility of me-

chanical engineers for membership, offered the following resolution, — "*Resolved*, that it should be the sense of this meeting that a clerical error had been made in transcribing the minutes of the meeting of January 3, 1898, in that the word 'mechanical' had been omitted, and that Article 3 of the Constitution should read as reported by Committee on Revision and as passed preliminarily December 6, 1897"; carried unanimously.

The Secretary then took the floor and read the Resolutions drawn up by the two committees appointed to take proper action with regard to the death of member Horace Ebenezer Horton and honorary member Edwin Ellis Woodman; these Resolutions as reported elsewhere were unanimously passed.

The Secretary was further instructed to obtain photographs of Messrs. Horton and Woodman, and to forward these together with the biographies of these members to the Association JOURNAL: also to send copies of Resolutions to the families of these members.

Balloting for members then followed: Junior member C. M. Colestock, assistant in office of City Engineer Claussen, was elected to full membership. Messrs. M. D. Thompson, bridge designer in the office of City Engineer Claussen; Alfred Peterson, formerly assistant engineer with the Chicago Great Western Railway, and E. M. Lewis, assistant engineer for the Chicago Great Western Railway, now in charge of the New Mississippi River bridge at St. Paul, were also elected to full membership.

Some remarks were made by Mr. Danforth in regard to allowing the Minnesota Surveyors' and Engineers' Society joint use of our society rooms, but no action was taken by the Society in regard to this.

President Fraser, of the Minnesota Surveyors' and Engineers' Society, was given opportunity to address the members of this Society with regard to the desirability of holding a joint meeting the latter part of January — this Society to defer its annual banquet until such date as might be agreeable to both. A motion was made by Mr. Herrold to this effect, and was accordingly carried. Subsequently, a motion was made by Mr. Starkey that a committee of three be appointed to confer with a similar committee from the Minnesota Surveyors' and Engineers' Society to perfect arrangements for a joint meeting as outlined by Mr. Herrold's motion.

Mr. Carroll suggested the Commercial Club Rooms as a suitable place to hold the banquet; this, however, was left to the committee to decide.

A committee consisting of Messrs. King and Herrold, the third member to be announced later, was appointed to represent the Society at a joint conference.

This completed the evening's business and adjournment was taken about 10.45.

L. S. POMEROY, *Secretary*.

HORACE E. HORTON.

Whereas, it has pleased Almighty God, in his all-wise providence, to remove from our midst our esteemed member, Horace E. Horton,

Therefore, be it resolved, that this Society deeply deplores his loss.

That we recognize his career to have been one of extraordinary ability as an engineer, and of sterling worth as a man, and that while we bow to the divine will, it is with profound sorrow that we erase from our membership roll the name of Horace E. Horton.

Be it further resolved, that a copy of this resolution be placed upon the Society's records, and a copy sent to each of the members of the bereaved family.

OSCAR CLAUSSEN,
W. L. DARLING,
C. J. A. MORRIS,
Committee.

EDWIN ELLIS WOODMAN.

Resolved, that by the death of Edwin Ellis Woodman this Society has lost an able and valued member.

Although since his retirement from railroad work in St. Paul we have not had the benefit of his attendance at our meetings, still, from our past association with him, we had come to recognize in Captain Woodman great mental gifts and talents for the conduct of affairs beyond the scope of his profession. He was not only a learned engineer and a man of general and liberal culture and genial disposition, but possessed rare qualities which made him a most valued business associate and highly appreciated companion and friend. To his fine attainments and genial character were added the tender sympathy and considerate regard of a warm and benevolent disposition, which found pleasure in the welfare and happiness of others and especially endeared him to the members of his family, to whom, in their bereavement, we extend our sincere sympathy.

CHARLES W. JOHNSON.
H. E. STEVENS.
T. MILTON FOWBLE.
DWIGHT C. MORGAN.
N. D. MILLER.

Montana Society of Engineers.

BUTTE, MONT., NOVEMBER 9, 1912. — President Robt. A. McArthur called the meeting to order. Present: McArthur, Moore, Packard, Cochrane, Leggat, Moulthrop, Alexander, Gillie, Sewall, Simons, McMahon, E. H. Wilson, Corry, Bacorn. Three visitors. Minutes approved as read. Messrs. Daoust and Richter elected to membership. Application for membership of John G. Cunningham read, approved and ballot ordered. Messrs. Blackford, Davis and Miller were appointed delegates to the annual convention of the American Road Builders' Association to be held in Cincinnati, Ohio, December 3–6, 1912. Various communications were read by the Secretary and referred to him for replies. Mr. Oscar Rohn gave a very interesting account of his experiences in road building in Silver Bow County. At the conclusion of his remarks an extended and valuable discussion of the topic followed, as well as the consideration of a "New Road Law" for Montana. The last subject was referred to the Secretary for action in conjunction with the Road Law Committee appointed by President Mathewson of the Good Roads Congress.

Adjournment.

CLINTON H. MOORE, *Secretary.*

Louisiana Engineering Society.

DECEMBER 9, 1912. — The meeting was called to order at 8.35, with President Anderson in the chair and 34 members and guests present. The minutes of the last meeting were read and approved.

After several informal announcements, a ballot nomination for officers for the ensuing year was held. As a result of the ballot, the following officers were nominated:

For President — Mr. A. M. Shaw.
For Vice-President — Mr. Wm. H. Williams.
For Treasurer — Mr. Ole K. Olsen.
For Secretary — Mr. J. M. Robert.
For Member on Board of Direction — Mr. A. T. Dusenbury.

The technical exercises of the evening were next in order, and Mr. Herman Kokosky read an excellent paper on "The Reproduction of Drawings by Natural and Artificial Illumination." After the paper was finished, Mr. Kokosky was tendered a rising vote of thanks by the Society.

There being no further business, the meeting adjourned to the usual collation.

JAMES M. ROBERT, *Secretary.*

Association

of

Engineering Societies

Vol. L. FEBRUARY, 1913. No. 2.

PROCEEDINGS.

Engineers' Club of St. Louis.

The 730th meeting of the Engineers' Club was the annual dinner of the Club and Associated Societies, and was held at the City Club on Wednesday, December 18, at 7 P.M.

There were 140 present.

The program consisted of talks by President Langsdorf, President-elect Hunter, Col. E. D. Meier, Prof. A. A. Young and Mr. F. N. Jewett, after which the Entertainment Committee presented an interesting farce, entitled "The Investigating Committee."

The Committee on Revision of the preamble of the Constitution reported, and a new committee was authorized to rewrite the Constitution and By-Laws and secure articles of incorporation for the Club.

Adjourned 10.15 P.M.

W. W. Horner, *Secretary.*

The 731st meeting of the Engineers' Club was held at the Club rooms at 3817 Olive Street, on Wednesday evening, January 8, at 8.15 P.M., as a joint meeting with the St. Louis Section of the American Society of Engineering Contractors. There were 44 members and 15 guests present.

President Hunter opened the meeting, and all business of the Club being suspended, resigned the chair to Mr. Greensfelder of the A. S. E. C., who presided during the reading of the paper.

Mr. J. E. Conzelman, chief engineer of the Unit Construction Company, presented an illustrated paper on "Unit Methods of Concrete Construction."

Mr. Conzelman described in detail the Unit System, and showed views of many examples in mill building and warehouse construction.

The paper was interrupted at intervals to permit of general discussion.

Adjourned 10.45 P.M.

W. W. Horner, *Secretary.*

Montana Society of Engineers.

BUTTE, MONT., DECEMBER 14, 1912. — The Society met for the current month at the usual hour, with President Robt. A. McArthur in the chair. Present, McArthur, Goodale, Kyd, Simons, Dunshee, Moore, Bard. Minutes of last meeting approved. John G. Cunningham was elected to membership in the Society. The Secretary reported that Messrs. Miller and Blackford were not able to attend "The Good Roads Congress," held at Cincinnati, Ohio, as delegates of the Society, the former for business reasons and the latter because of absence from the United States. Six members were suspended for non-payment of dues for the past three years. A discussion of "A Good Roads Law" for the consideration of the next state legislature followed, and the Secretary was instructed to revise the one under consideration and have five copies made of the same. Messrs. Goodale, Moore and F. M. Smith were appointed a committee to consider the advisability and expense of having the same printed and distributed to the Society. Adjournment.

CLINTON H. MOORE, *Secretary.*

Louisiana Engineering Society.

ANNUAL MEETING, JANUARY 11, 1913. — The meeting was called to order at 8.25, with President Anderson in the chair and a large number of members and guests present.

The minutes of the previous meeting were read and approved.

The reports of the Secretary, Treasurer and Board of Direction were read, approved and ordered through the usual course.

Messrs. Seaver, Barelli and Okey were appointed tellers to open ballots for officers for the ensuing year. Their report was as follows: There were 76 formal ballots and 2 informal, which resulted in the election of the following officers:

President — Mr. A. M. Shaw.

Vice-President — Mr. Wm. H. Williams.

Secretary — Mr. James M. Robert.

Treasurer — Mr. Ole K. Olsen.

Board of Direction — Mr. A. T. Dusenbury (to serve three years).

The next president, Mr. Shaw, was then conducted to the chair by Mr. Datz.

Upon motion of Mr. Coleman, duly seconded, the Chair was requested to appoint a committee to arrange for the next meeting of the American Society of Civil Engineers in New Orleans.

Upon motion of Mr. Datz, duly seconded, a vote of thanks was tendered to the retiring officers of the society.

There being no further business, the meeting adjourned to Galatoire's for the annual banquet.

JAMES M. ROBERT, *Secretary.*

Oregon Society of Engineers.

THE quarterly dinner and regular monthly meeting of the Society were held on Thursday, October 10, 1912, at the Imperial Hotel, the general meeting following the dinner, which was served at 6.30.

About forty members were present, and the President, Mr. D. C. Henny, presided. Two representatives of the press were also present as guests of the Society.

The Committee on Good Roads submitted a report and recommended certain bills to be voted for at the coming election. A lively discussion followed the presentation of this report.

The main feature of the program was the reading of a paper by Mr. T. M. Hurlburt, city engineer, the title being "The Sewer System, Present and Proposed, for the City of Portland."

A long and interesting discussion followed the reading of Mr. Hurlburt's paper, and a vote of thanks was tendered to him.

Meeting adjourned.

F. A. NARAMORE, *Secretary.*

A SPECIAL meeting of the Oregon Society of Engineers was called and held at the rooms of Portland Architectural Club, 247½ Stark Street, on Monday, November 4, 1912, at 8 o'clock P.M.

The meeting was called to order by Vice-President W. S. Turner, who stated that the purpose of the meeting was to vote on the advisability of coöperating with the other technical societies of this city in order to secure joint quarters, the rooms in which the meeting was held at present belonging to the Portland Architectural Club, being available.

A quorum not being present, no business was transacted; but it was the sense of the meeting that the report of the committee appointed to canvass the situation in regard to quarters be adopted.

Meeting adjourned.

O. E. STANLEY, *Secretary pro tem.*

A REGULAR meeting of Oregon Society of Engineers was held at the rooms of Portland Architectural Club, on Thursday, November 14, 1912, at 8 o'clock P.M., about 27 members being present, as well as several visitors.

Vice-President W. S. Turner presided.

The matter of a joint agreement with Portland Architectural Club regarding the use of the Club's quarters by the Society was discussed, but no definite action was taken on account of lack of a quorum. The sense of the meeting was that the Executive Board should send out letter ballots to determine the will of the entire Society in regard to this agreement.

A very exhaustive paper, prepared by Mr. G. B. Hegardt, engineer of Public Docks Commission of Portland, on the subject of "Portland, Oregon: Its Channel Approach, Harbor, Railroad Facilities, Navigable Waterways and

Tributary Territory," was read before the meeting and a discussion of the subject-matter followed.

A vote of thanks was tendered Mr. Hegardt, and the meeting then adjourned.

F. A. NARAMORE, *Secretary.*

THE regular monthly meeting of Oregon Society of Engineers was held at the rooms of Portland Architectural Club, 247½ Stark Street, Portland, Ore., on Thursday, December 19, 1912, at 8 o'clock P.M., about 35 members and 10 visitors being present.

President D. C. Henny presided, and the minutes of previous meetings were read and approved.

The result of the letter-ballot on the question of coöperation with Portland Architectural Club in the matter of club rooms was announced as follows:

Votes in favor of proposition	106
Votes in favor of proposition (conditional)	1
	107
Votes against proposition	None

Mr. Turner, chairman of the committee on coöperation with the Architectural Club, read the report of his committee; and the agreement between the Architectural Club and Oregon Society of Engineers, relative to the joint use of the club rooms at 247½ Stark Street, under the name of "Oregon Technical Club," was read by the Secretary.

The report of the Nominating Committee, submitting the names of Paul A. Schuchart, H. L. Vorse, D. W. Taylor and W. P. Hardesty, to be voted on as members of the Board of Governors of Oregon Technical Club to represent the Oregon Society of Engineers, was read; and upon motion the nominations were declared closed. A ballot was taken, resulting in the election of Mr. Schuchart and Mr. Vorse as members of the Board of Governors.

Upon motion of Mr. Monteith, seconded and carried, the initiation fee was suspended for a period of six months from December 16, 1912.

Mr. Brookings, president of Progressive Business Men's Club, addressed the meeting upon the desirability of coöperation among clubs in matters of public interest, suggesting that the Oregon Society of Engineers would be specially fitted to deal with matters relating to streets, sewers, bridges, harbors, etc., and requesting the Society's assistance in getting the questions of public comfort stations and municipal loan association properly before the people.

Upon motion of Mr. Morton, seconded and carried, a vote of thanks was tendered to Mr. Turner for his excellent work upon the committee to coöperate with other technical societies in the matter of quarters.

Mr. Monteith spoke of the desirability for an engineers' and surveyors' state license law.

Mr. John T. Whistler addressed the meeting on the subject "Some of Our Water Resources," taking up in turn the questions of Irrigation, Water Power, Potable Supply, Fisheries and Navigable Streams. He stated that there are at present one and a half million acres in Oregon under irrigation

or water rights applied for; that the annual economic loss to the state from water-borne diseases is from four to six million dollars; that there are 600 miles of navigable streams in and bordering upon the state, and that four million dollars' worth of freight passes Cascade Locks annually. He mentioned the fact that engineers were generally accused of making estimates for irrigation projects too low, and offered, as an explanation, that the engineer usually neglected to call the attention of the promoter to the cost of marketing the lands and carrying the investment until the land was sold.

Mr. W. H. Graves and Mr. D. C. Henny discussed some of Mr. Whistler's statements.

Moved by Mr. Graves, seconded and carried, that a vote of thanks be tendered to Mr. Whistler for his very interesting talk.

Meeting adjourned.

O. E. Stanley, *Secretary pro tem.*

Association of Engineering Societies

Vol. L. | MARCH, 1913. | No. 3.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., January 22, 1913. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.45 o'clock, President James W. Rollins in the chair; about 225 members and visitors present, including members of the American Society of Mechanical Engineers and members of the Boston Section of the American Institute of Electrical Engineers.

By vote the reading of the record of the December meeting was dispensed with and it was approved as printed in the January *Bulletin*.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grades named: members, Messrs. Arthur P. Porter and Leslie Jack Wertheim, and as a junior, Mr. Philip Curtis Nash.

The President announced the death of Francis Blake, a member of the Society, who died January 19, 1913, and by vote the President was requested to appoint a committee to prepare a memoir. The President has named as that committee, Mr. Desmond FitzGerald.

On motion of Professor Porter, it was voted that the chair be requested to appoint a committee of three to report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The chair appointed as that committee, Messrs. Dwight Porter, Henry B. Wood and Robert R. Evans. Later in the meeting this committee reported the following names as members of the Nominating Committee: Messrs. Charles T. Main, George A. Carpenter, Arthur W. Dean, Laurence B. Manley and Frank A. McInnes, and by vote they were elected as the Nominating Committee.

Mr. Charles Freed brought before the meeting the question of endorsing the project of the Lincoln Memorial Highway Association, for building a highway between Washington and Gettysburg. But after a discussion and a ruling that it would be necessary, under the constitution, to pass such an endorsement at two meetings, it was withdrawn.

The meeting then took the form of a joint meeting, in which members of the American Society of Mechanical Engineers and of the Boston Section of the American Institute of Electrical Engineers took part.

President Rollins introduced the speaker of the evening, Mr. William H. Lewis, president of the Lewis-Wiley Hydraulic Company, of Seattle, Wash., and Portland, Ore., who gave an exceedingly interesting talk on "Hydraulics in City Building," which was profusely illustrated by lantern slides.

Mr. Lewis described the work done by his company in Seattle, whereby, at Denney Hill and at Jackson Street Hill, grades of 15 to 20 per cent. were reduced to grades of 3 to 5 per cent., and the material at the same time used to fill the tide lands on the water front, which now constitute the entire terminals of the Great Northern, the Northern Pacific, and the Union Pacific railroads. Its work in Portland has been that of reducing a rough and inaccessible hill by hydraulic terracing and so converting it into the choicest residential portion of the city. This work was done under the plans of Olmsted Brothers, of Brookline.

The distinctive features of the work done by Mr. Lewis's company are: *First*, the moving of so large an amount of dirt (17 000 000 yd.) in the heart of a city; *second*, the low cost of the work done by the hydraulic method as compared with moving it dry; *third*, the building of permanent, solid embankments with $1\frac{1}{2}$ to 1 slopes by hydraulic methods and without slides or slump-outs occurring; and *fourth*, the carving out from the rough hillside an ideal residence section in the heart of a large city.

The regrading done by hydraulic methods under contract with the city of Seattle was at a flat price of less than 25 cents a yard, in most cases covering the grading of streets on the hills and the filling of streets on the tide flats, the price to cover the entire cost. This was done, and the sides of the hill were covered with buildings ranging from the one-story frame cottage to the 20-story brick school building, all of which had to be moved away or destroyed. The filled streets were raised on trestles to as high as 46 ft. above the original grades, and then filled to the true grade by the hydraulic method. Many large buildings were raised in the same way, and the dirt turned under them; the foundations and underpinning put on posts and piles and then the dirt put in under and around the foundations by water.

As to the cost, the work done by city contract where there was not sufficient grade to carry the earth away by sluicing was done with steam shovels and cars at a contract price of over 55 cents per cu. yd., whereas the millions of yards moved by hydraulics cost from 20 to 27 cents per cu. yd.

In the building of embankments, the company raised the level of city streets 60 ft. wide as high as 50 ft. above the muck bottom of the flats and maintained the slopes on a $1\frac{1}{2}$ to 1 basis, the fill being made of blue clay delivered through pipes. In the Portland work, the company built embankments 90 ft. high on $1\frac{1}{2}$ to 1 slopes, raising them at the rate of more than 2 ft. per day, and has yet to suffer its first loss through slipping or sliding of a completed embankment. This has been done through the step or sheer board bulkhead method and by keeping the water so far as possible out of the embankment.

The methods used by Mr. Lewis's company are well adapted to the building of earth dams, and his company is at present undertaking contracts for the construction of several such dams in different parts of the West during the coming year.

One remarkable feature of Mr. Lewis's work is that neither he nor his

partner, Mr. Charles S. Wiley, deceased, were engineers, nor had they any engineering or mechanical training. They were young lawyers in Seattle when they undertook their first hydraulic work for the purpose of improving a small piece of property which they owned on one of the high hills in Seattle. Starting in this experimental way, their work increased from year to year, until at the present time they are the leaders in the sluicing method of moving dirt, and have built up a valuable organization through ten years of actual experience in all kinds of material and under diverse conditions.

An interesting discussion followed Mr. Lewis's talk, brought out by the many questions asked, and at its close Mr. Lewis was accorded a unanimous vote of thanks for his very interesting and instructive lecture.

Adjourned.

S. E. Tinkham, *Secretary*.

Special Meeting of the Sanitary Section.

Boston, Mass., January 8, 1913. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in Social Hall, Tremont Temple. Chairman George C. Whipple called the meeting to order at eight o'clock, introducing Prof. R. C. Carpenter, of the Department of Experimental Engineering of Cornell University, as the speaker of the evening. Professor Carpenter's paper on "Ventilation" contained a careful detailed description of the theories and data upon which modern practice in ventilation is based.

The discussion was opened by Mr. D. D. Kimball, heating and ventilating engineer of New York City. Mr. Kimball spoke from experience with various ventilating problems, and referred particularly to the New York school experiments.

Mr. M. C. Whipple, of the Sanitary Engineering Department of Harvard University, described briefly a series of analyses made on air washer water at Springfield, Mass.

Prof. Earle B. Phelps gave an account of the experimental work now under way at the Massachusetts Institute of Technology.

Others who participated in the discussion were Messrs. G. C. Whipple, R. S. Weston, Edward Wright, Jr., and Gifford LeClear.

A vote of thanks was extended to Professor Carpenter, Mr. Kimball and Mr. LeClear, for the valuable information they had contributed.

The attendance was 50. Meeting adjourned.

Frank A. Marston, *Clerk*.

Special Meeting of the Sanitary Section.

Boston, February 5, 1913. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in Gilbert Hall, Tremont Temple. The meeting was called to order at eight o'clock by Chairman George C. Whipple. Following the custom established last year, the chairman stated that unless there were objections raised, he would appoint a nominating committee to act informally and report at the regular March meeting. No objections were offered and the chairman appointed the following members: Messrs. Edward Wright, Jr., H. K. Barrows and R. S. Weston.

The chairman stated that he had received word from Mr. Edwin A. Fisher, city engineer of Rochester, to the effect that business engagements prevented his being present at the meeting to read the paper on the Rochester, N. Y., intercepting sewer, as advertised, but that he would be glad to present the paper to the Society for publication.

Mr. Glenn D. Holmes, chief engineer of the Syracuse Intercepting Sewer Board, was then introduced and gave a very interesting illustrated paper on the intercepting sewer work and river improvements which have recently been carried on in Syracuse, N. Y.

Mr. William F. Williams gave a very interesting talk, illustrated by a large number of lantern slides, upon the intercepting and outfall sewer, now under construction at New Bedford, Mass. Mr. Williams, although at present chief engineer of the Massachusetts Harbor and Land Commission, still retains supervision over this work, which was started while he held the office of city engineer. The screen chamber construction and method of laying the submerged outfall sewer contained many features of special interest.

Mr. David A. Hartwell, chief engineer, of the Sewage Disposal Commission of Fitchburg, presented a paper on the Fitchburg intercepting sewer which has been under construction for the past two years. Aside from the general details of the sewer construction, the features of special interest were the siphon chamber and the grit chamber. The latter especially being of an unusual type.

A vote of thanks was extended to the speakers for their courtesy in presenting the valuable papers of the evening.

Considerable interest was shown throughout the evening and although many of the men came from out of town, the majority stayed through the long program until the meeting adjourned at 10.20 o'clock. The attendance was 64.

Frank A. Marston, *Clerk.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., January 13, 1913. — The thirtieth annual meeting of the Civil Engineers' Society of St. Paul was held in the Society rooms, January 13, 1913, President D. F. Jurgensen in the chair. There were present twenty-seven members.

After the reading and approval of the minutes of the December meeting, some remarks were made by Mr. Danforth explaining his reasons for his suggestion at the December meeting of allowing the Minnesota Surveyors and Engineers' Society joint use of our Society rooms. His remarks were followed by other members along the same line, and a motion was finally submitted by Mr. Herrold that a committee be appointed to look into the project and report at the next meeting. The motion was carried but appears to have been lost sight of in the discussion which followed, and no committee was appointed.

Mr. L. P. Wolff reported for the committee appointed to confer with the Minnesota Surveyors and Engineers' Society with regard to a banquet at which they are to be guests of the St. Paul Society as follows: Such banquet to be held on the evening of February 12, at the Ryan Hotel, expense $1.25 per plate, to be borne exclusively by the St. Paul Society. Mr. Wolff's report was followed by a humorous presentation by Mr. Herrold of a letter

he had received from a vaudeville performer in regard to furnishing entertainment for this occasion. Mr. Palmer offered a motion authorizing the banquet committee to devise means to raise funds for defraying the expenses of the banquet, inasmuch as these could not be met out of the funds now in the treasury. Mr. King supplemented this by a move to start a subscription list among those present at once. Mr. King's motion precipitated a very spirited discussion, raised by a suggestion from the President earlier in the evening, that the Society depart from its custom of serving no intoxicants on this occasion, Mr. Danforth ably sustained by seven other members rigorously protesting against any departure from the custom, which had been initiated by a resolution on the Society records of date November 18, 1905, and strictly adhered to ever since. The President, being of a Progressive cast of mind, did not believe in the Society's allowing its hands to be tied by antiquated precedent, and argued that this was a special occasion requiring special treatment. This discussion finally resulted in a motion by Mr. Armstrong that champagne be added to the bill of fare. This was carried, 15 voting "yes" and 8 "no," 4 not voting.

Objections by Mr. Claussen to the method outlined of defraying the expenses of the banquet resulted in a motion by Mr. King that each member of the St. Paul Society attending the banquet be assessed $1.50 to pay for his own plate. Carried.

Some discussion followed in regard to inviting the Minneapolis Engineers' Club to be present at this banquet, on the same condition as the St. Paul Society, Mr. Carroll maintaining that this ought to be done. This, however, was left to the discretion of the committee, who decided against it.

Balloting for members then followed. The names of Julius H. Goos, rail inspector for the Great Northern Railway; Walter M. Murphy, engaged in drainage work at Floodwood, St. Louis County, Minn.; and Edward R. Schafer, of the city engineering staff of St. Paul, were proposed for membership. On motion duly seconded by Mr. Palmer, the Secretary was instructed to cast the ballot of the Society admitting them to membership.

Election of officers came next in order. First ballot for President resulted as follows: J. H. Armstrong, 13; D. F. Jurgensen, 6; A. F. Meyer, 4; scattering, 4. Mr. Armstrong lacking only one vote of the necessary majority, it was moved and seconded that he be declared duly elected, which was accordingly done. The ballots were accordingly prepared for Vice-President, the first resulting as follows: A. F. Meyer, 6; J. F. Druar, 6; G. H. Herrold, 5; A. R. Starkey, 3; J. E. Carroll, 3; scattering, 4. Five subsequent ballots were cast, no choice resulting. On the seventh and final ballot A. R. Starkey received 17 votes; J. F. Druar, 5; A. F. Meyer, 4; E. S. Spencer, 1. Mr. Starkey was declared duly elected. Upon motion duly carried it was voted that the President be instructed to cast the ballot of the Society for the present incumbents for the offices of Secretary, Treasurer and Librarian, which was accordingly done.

Mr. L. P. Wolff was nominated and elected by acclamation to represent this Society on the Board of Managers of the Association of Engineering Societies.

The newly elected President then took the chair, and the annual reports of the Secretary, Treasurer and Librarian followed. These were ordered published and are appended hereto and made a part of the minutes of this meeting. The report of this Society's representative on the Board of Managers of the Association of Engineering Societies having been duly read and accepted,

a motion by Mr. Wolff that the thanks of the Society be extended to the retiring officers was duly carried and the meeting adjourned at 10.30 P.M.

L. S. POMEROY, *Secretary.*

ANNUAL REPORT OF THE SECRETARY FOR THE YEAR 1912.

JANUARY 13, 1913.

As Secretary of the Civil Engineers' Society of St. Paul, I have the honor to submit the following report for the year terminating for this Society on December 11, 1912, which was our last regular meeting for the year now gone.

On January 8, 1912, when the undersigned was duly elected Secretary, our membership consisted of 53 resident full members, 3 resident junior members, 31 non-resident full members, 2 non-resident junior members, one resident and one non-resident honorary member, making a total membership of 91. At present we have 68 resident full members, 2 resident junior members, 38 non-resident full members and 2 non-resident junior members, with one resident honorary member, making a total membership at this writing of 111 members.

Accessions to our membership during the year have been as follows: January, 2 members; February, 1 member, and one transfer from the grade of junior to that of full member; March, 3 members; April, 1 member; May, 5 members; October, 6 full members and one junior; November, 2 members; December, 3 members and one transfer from junior to full member. Total accessions, 23 members, one junior.

During the same period we have lost two members on account of the urgent call of the new Northwest for skilled engineers, Messrs. H. C. Palmer and T. M. Comfort having resigned to engage in business in Saskatchewan province; also two of our most renowned and formerly very active members, the one still ranking as an active member, while the other had been transferred to the grade of honorary member, have responded to the call of death. Messrs. H. E. Horton and E. E. Woodman were both men of national reputation, and this Society may well be proud of having retained them on its roll until removed from it by the " Grim Reaper," the advances of whom no one can hope to forestall, and in this hour of coming together, no one who knew them can be otherwise than saddened at the thought that henceforth our Society must proceed without their wise counsel and coöperation.

At the eight regular meetings we have had read and discussed papers on the following very practical subjects: " Water Power Resources in Minnesota "; " Suggested Remedial Legislation Regarding the United States Patent Laws "; " Railroad Wrecks "; " The Art of Water Purification "; " Descriptive Illustrations of the Panama Canal "; " Railroad Valuation, Reproduction Cost New as a Sole Basis for Rates "; " The Process of Creosoting Timbers and Paving Blocks." Four of these papers have already been published in the Association JOURNAL, and it is hoped that the others may be in the near future.

ATTENDANCE.

Attendance, particularly at the fall meetings, has been extremely gratifying, twenty-four members and approximately one hundred visitors having attended the October meeting, and twenty-six members and fifteen visitors having attended the December meeting. At no time has it been necessary to

adjourn for lack of a quorum, the smallest number attending being nine, at the April meeting.

Mention might here be made of the two excursions during the summer months, — the one to the Twin City Brick Company's plant on August 3, when as many of the Society as cared to avail themselves of the opportunity were royally entertained by a taxi-cab trip hither, and were shown in detail all the intricacies of brick and tile manufacture, thanks for which were due to our esteemed fellow-member, Mr. G. W. Rathjens. On August 24, a party sufficiently large to require the services of six automobiles made an excursion to Taylors Falls, where the beauties of the Interstate Park were expounded to the Society by Commissioner Hazzard and the magnificent generating plant of the Minneapolis General Electric Company on the opposite shore of the St. Croix was explained in detail by Superintendent Robinson, thanks to both of whom have been officially rendered by the Society through the Secretary. For both of these excursions, the Secretary feels that acknowledgment is due to the tireless energy of the chairman of our Entertainment Committee, Mr. W. E. King.

Commendation is also due the membership committee through whose efforts many names have been added to our membership roll during the year. While we still remain at the bottom of the list in the Association, no discouragement need be felt at this since the cities of Boston, St. Louis and Detroit are considerably ahead of St. Paul in population and by reason of their older environment might naturally be expected to show more strength in the engineering profession, even if this were not the case, and the remainder are state-wide organizations. On the whole, no doubt exists in the mind of the Secretary that the year 1912 has closed with the Civil Engineers' Society of St. Paul having made a very creditable record, and it is to be hoped the record yet to be made for 1913 may even eclipse this.

Very respectfully submitted,

L. S. Pomeroy, *Secretary.*

Treasurer's Report for 1912.

Receipts.

Cash on hand January 8, 1912		$132.51
Collections		
Dues for years previous to 1912	$30.50	
Dues for 1912	315.84	
Journal subscriptions for 1912	98.13	
Initiation fees	122.00	
Accounts overpaid	9.50	
Back numbers of Journals sold	3.10	
Badges sold to members	81.05	
Trip to Taylors Falls	29.50	
		689.62
Total receipts		$822.13

Disbursements.

For Assessments, JOURNAL ASSOCIATION ENGINEERING SOCIETIES	$156.44	
For subscriptions to engineering periodicals	52.00	
For printing and stationery	76.00	
For binding	35.50	
For entertainment	103.75	
For stenographic services	60.83	
For postage	42.18	
For janitor for club rooms	55.00	
For insurance on library	12.00	
For new bookcases	19.00	
For Society gold badges	103.95	
For miscellaneous items	20.60	
		737.25
Balance on hand		$84.88

Resources.

Deposit in First National Bank		$84.88
Badges on hand (12)		18.00
Ledger accounts due the Society:		
Dues for years previous to 1912	$53.50	
Dues for 1912	97.50	
JOURNAL subscriptions	12.63	
Initiation fees	10.00	
Badges	2.60	
		176.23
Total resources		$279.11

Liabilities.

None	00.00
Net resources	$279.11

Respectfully submitted,

OSCAR PALMER, *Treasurer.*

Dated JANUARY 13, 1913.

ANNUAL REPORT OF THE LIBRARIAN FOR THE YEAR ENDING JANUARY 13, 1913.

Text-books in library	194 volumes
Bound periodicals	332 volumes
Bound reports and miscellaneous work	407 volumes
Total bound volumes	933 volumes

Increase for 1912.

Text-books	1 volume
Periodicals bound	28 volumes
Reports, etc., received	10 volumes
Total increase	39 volumes

Bookcases on Hand.

Old-style cases (4), value	$85.00
Sectional cases (30 units, 6 tops, 6 bases), value,	114.00
Magazine rack	7.00
	$206.00
Value of 933 volumes, at $5.00	4 665.00
Total value of library	$4 871.00

We now have on our reading table the following periodicals: *Engineering News*, *Engineering Record*, *Railway Age Gazette*, *Municipal Journal*, *Good Roads*, *Concrete Cement Age*, JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, Transactions of the American Society, Transactions of the Society of Western Pennsylvania, *Journal of the Western Railway Club*, Transactions of the Cleveland Society, *Professional Memoirs*, *Panama Canal Record*, Transactions Nova Scotian Institute of Science, bulletins University of Illinois, Idaho Society Journal, Utah Society Journal.

Also a large number of reports and bulletins on engineering subjects.

OSCAR PALMER, *Librarian.*

Dated JANUARY 13, 1913.

Montana Society of Engineers.

BUTTE, MONT., JANUARY 11, 1913. — The meeting was called to order by President Robert A. McArthur. Members present: Dunshee, Packard, Moore, McArthur, Kemper. The December minutes were approved without change. The application for membership of Robt. A. Ricketts was read, approved and ballot ordered. The Secretary read the resignations of Messrs. Thorpe and Elliott, which were accepted, and the name of Wm. Wraith was ordered placed on Corresponding Membership list, if so desired. The chair appointed the following committees: Resolutions on death of Frank A. Jones, Messrs. Whyte, Lemmon, Blake; nominations of officers for ensuing year, Messrs. Whyte, Dunshee, Frank M. Smith. The Secretary stated that in the name of the Society he had requested Representative Pray to support the Lincoln Highway Memorial in Congress and the Society approved the action of its Secretary. The Secretary was instructed to revise the Year Book of the Society. The Committee on Preparation of a General Highway Law reported that the work had been done and the bill introduced in the legislature by Wm. J. McMahon, a member of the Society. Adjournment.

CLINTON H. MOORE, *Secretary.*

Utah Society of Engineers.

January 17, 1913. — The regular meeting of the Utah Society of Engineers was held in the Society Room, 702 Newhouse Building; meeting called to order at 8.00 p.m. by President Brown.

Announcement was made by the President of request that the Society vacate its quarters.

The following were elected as members: Murray Sullivan, office engineer, Oregon Short Line, Salt Lake City; Samuel S. Arentz, superintendent of construction, Inter-Urban Construction Co., Salt Lake City: as juniors: R. O. Dobbs, student, University of Utah, Salt Lake City; Vernon W. Dean, student, University of Utah, Salt Lake City; Wilford W. Clyde, student, University of Utah, Salt Lake City.

The following program was given: " Petroleum Crude Oils and Their Refining Value," by J. C. Howard, president of Utah Oil Refining Company; " Geology of the Oil Fields of Utah," by Dr. F. J. Pack, professor of geology of University of Utah. Discussion led by Dr. W. C. Ebaugh.

About 80 members present.

Adjourned.

R. B. Ketchum, *Secretary.*

Association of Engineering Societies

Vol. L. APRIL, 1913. No. 4.

PROCEEDINGS.

Association of Engineering Societies.

The letter ballot of the Board of Managers which closed March 1, 1913, resulted unanimously in favor of both of the propositions submitted. No ballots were received from the representatives of the Louisiana Engineering Society and the Utah Society of Engineers, but all the ballots that were received were in the affirmative. The effect of the vote upon the first question is to terminate the permission to constituent societies to obtain a commission upon advertisements procured by them respectively. It was voted to rescind the former Rule 26 which was as follows:

"26. Advertisements procured for the Journal by the societies composing the Association shall be charged to those societies, less 90 per cent. commission."

The second question was decided by the adoption of the following new Rule 3:

"3. In case the numbers upon the mailing lists for the two months next succeeding the rendering of a quarterly bill, that is to say, for the Journals of January and February, of April and May, of July and August, or of October and November, should differ from the numbers charged to any Society upon that quarterly bill, a corresponding allowance shall be made in connection with the next following quarterly assessment, provided, that demand therefor be made by either party, the Society or the Association, so as to be received by the secretary of the other party within three weeks of the time when the last mailing list, viz., for February, May, August or November Journal, is mailed by the Secretary of the Association to the address of the Secretary of the Society."

Fred. Brooks, *Secretary.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., February 10, 1913. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held in the Society rooms in the Old State Capitol on the evening of February 10, with President J. H. Armstrong in the chair; present, 19 members and 4 visitors.

By unanimous consent of those present it was voted to allow Mr. E. A. Goetz, the speaker of the evening, to proceed with his lecture on "Kinks in Structural Drawings and Shop Details" before the business meeting, this to enable Mr. Goetz to fill other engagements later in the evening. Mr. Goetz explained in some detail the necessity of following some uniform system of notation in making shop drawings, and elaborated upon what system he had found most useful in his experience as chief draftsman for a large structural concern. He also sketched the St. Paul Foundry in plan on the Society's blackboard, and explained in detail how material is there handled to obtain the best results with the least expenditure of time and energy. Mr. Goetz occupied something like an hour in this manner, after which the business affairs of the Society were taken up.

A motion was made by Mr. Jurgensen and duly supported that a vote of thanks be extended to Mr. Goetz for the trouble he had been to in preparing his discourse; carried unanimously.

The reading of the minutes of the last meeting came next in order; these were approved as read. The Entertainment Committee having no report to make at this time, the Treasurer was called upon to advise as to the amount of the fund thus far raised by popular subscription for defraying the expenses of the banquet to be given the Minnesota Surveyors' and Engineers' Society on the 12th, and reported that approximately $275 was already available.

The report of the committee consisting of Messrs. Kalk, Hogeland and Rasmussen, appointed to draw up a suitable resolution upon the death of member Edward C. Hollidge, which occurred January 20, was read by the Secretary and unanimously adopted. This resolution is appended to the minutes of this meeting.

Mr. Herrold next took the floor and advised the assembled company that an offer had been made this Society to allow it very appropriate accommodations for its library, and also for its meetings, in the new City Library building, on condition that the public be allowed the use of the library for reference purposes. This was referred to a committee consisting of Messrs. Herrold, Palmer and Druar.

Mr. G. W. Rathjens moved for the appointment of a committee to work for the amendment of the new St. Paul city charter, to the end that a qualified civil engineer might be eligible to fill the position of building inspector; this committee also to take up the question of the advisability of establishing a testing laboratory in St. Paul; also to urge that the St. Paul and Minneapolis building codes be made more nearly uniform. Mr. Rathjens' motion was amended to have these questions referred to the Society's Public Affairs Committee; carried as amended. Later a motion was made for the appointment of a special committee, consisting of Messrs. Rathjens, Jurgensen and King, to act as an advisory board in this same matter.

Balloting for members then followed. The names of John B. Mitchell, assistant engineer Great Northern Ry. at New Rockford, No. Dak., and present junior member of the Society; John H. Mullen, of St. Paul, deputy State Highway Commission; Frank R. Felming, of St. Paul, assistant engineer for the Claussen Engineering Company; Ernest A. Titus, of St. Paul, assistant engineer for the Northern Pacific Ry.; and Floyd D. Minium, city engineer of New Ulm, Minn., were proposed for membership. Upon motion duly carried by Mr. Palmer, the Secretary was authorized to cast the ballot of the Society admitting them to membership.

A letter from Mr. S. H. Hedges with regard to the desirability of this Society's holding a reunion in San Francisco in 1915 was read and ordered placed on file; one from the Brooklyn Engineers' Club offering a prize of $250 for the best scheme for reclaiming a portion of Coney Island Beach was similarly disposed of. This completed the business of the evening and adjournment was accordingly taken about 10.15.

L. S. POMEROY, *Secretary.*

RESOLUTION.

Whereas, our esteemed member Mr. Edward C. Hollidge has been taken away by death;

Resolved, that the St. Paul Society of Civil Engineers, in regular meeting assembled, express their great sorrow and also their appreciation of Mr. Hollidge's character as a man and engineer;

Resolved, that these resolutions be spread upon the minutes of the Society and a copy thereof be sent to the family of the deceased.

A. H. HOGELAND,
C. N. KALK,
A. J. RASMUSSEN,
Committee.

THE regular meeting of the Civil Engineers' Society of St. Paul was held according to custom on Monday, March 10, in the Senate Chamber of the Old Capitol. Present, 33 members and about 140 visitors.

The members and guests were royally entertained until about ten o'clock by Mr. Oliver Crosby, who gave a very instructive as well as entertaining lecture on the present status of the Panama Canal, which lecture was illustrated by views the negatives for which had been taken by himself on his recent trip to the Isthmus. Mr. Crosby dwelt at some length on the effect the recent slides were likely to have on postponing the date of completion of the canal, and also explained how the duplicate systems of locks would prevent the traffic through the canal ever being entirely suspended. The details of the locks were well illustrated and all felt better informed on this at present very live subject when the lecture was finished.

After the lecture a goodly number of the members present adjourned to the Society rooms, where a business meeting was held. Owing to the advanced stage of the evening, it was voted by motion of Mr. Starkey to dispense with the reading of the minutes of the last meeting.

Mr. Wolff, as chairman of the Banquet Committee, made a detailed report of the receipts and expenditures of this committee in connection with the banquet given on February 12 to the Minnesota Surveyors' and Engineers' Society, which report in full is hereto annexed. This report was, upon motion of Mr. Starkey, adopted by the Society.

Mr. Rathjens for the committee appointed to work with the Public Affairs Committee in regard to the matter of having certain amendments made to the new city charter, reported that two meetings had been held, and preliminary steps taken toward obtaining a working outline of the charter. He stated that several months might be necessary for this committee to complete its work. Upon motion by Mr. Palmer this report was accepted and the committee authorized to continue its work.

In the absence of Chairman Herrold of the committee appointed to look into the feasibility of a proposition made by the new Library Board, having for its object the housing of this Society in this edifice, Mr. Palmer made a verbal report substantially the same as the formal report hereto attached, which has come into possession of the Secretary since the meeting. It was voted by the Society to accept this report, and the committee was given further time to complete its work.

Mr. Claussen, for the Public Affairs Committee, offered the following resolution:

" *Whereas*, the water resources of the state of Minnesota constitute one of the greatest assets of our state; and,

" *Whereas*, investigations carried on by the state, working in coöperation with the United States Geological Survey, have resulted in the collection of much valuable information regarding these resources, which has been made accessible to all people interested; and,

" *Whereas*, the remarkably low flow of the streams of the state during the past two years has emphasized the great need for accurate determinations of stream flow extending over a number of years, in order that these records may be sufficiently comprehensive to warrant their use with confidence in the study of problems relating to water supply, water power, navigation and sanitary conditions; and,

" *Whereas*, the federal government has placed at the disposal of the state, with a view to coöperation, the efficient organization of the United States Geological Survey,

" *Therefore, be it resolved*, that, we, the Civil Engineers' Society of St. Paul, consider the continuation of the water resources investigation of Minnesota an important duty devolving upon the state, and respectfully urge upon our legislators that, in order to permit the discharge of that duty, an annual appropriation of not less than three thousand dollars be made to carry on, in coöperation with the federal government, these investigations, to the end that the necessary information may be secured for the fullest utilization of one of the greatest of our state's resources in the interests of all the people.

" *Be it further resolved*, that copies of this resolution be sent the Senate Committee on Finance (Frank Clague, chairman), House Committee on Appropriations (Andrew Davis, chairman), with the request that our Society be notified of any hearings which may be held for the consideration of a bill, Senate No. 420, by B. E. Sundberg."

This resolution was unanimously adopted by the Society, and the Secretary instructed to send copies of same to Hon. Frank Clague, chairman of the Senate Committee on Finance, and Hon. Andrew Davis, chairman of the Committee on Appropriations in the House.

It was suggested by Mr. Palmer that it might be well for the Society to take some action toward obtaining from the legislature an appropriation for the improvement of the Interstate Park at Taylors Falls. Upon motion of Mr. Jurgensen the Secretary was instructed to write Senator Elwell of the Finance Committe urging him to use his influence toward obtaining such an appropriation. The following resolution was submitted by Mr. Wolff as having been handed him by an interested party:

" *Be it and the same is hereby resolved*, that the Civil Engineers' Society of St. Paul purchase of the Minnesota Surveyors' and Engineers' Society one hundred copies of the 1913 Annual Report, at a price not to exceed thirty-five dollars, said money to be used to defray the expenses of a three-page write-up of the banquet with three full pages of cuts (two of the program, one of the banquet) and a page of advertisement of the Civil Engineers' Society of St. Paul."

Upon motion of Mr. King this resolution was ordered laid on the table. Subsequently it was moved by Mr. Starkey to reconsider this resolution. This motion was carried, and after a prolonged debate, which was participated in by Messrs. Jurgensen, King and Rathjens, and Ex-President Fraser, speaking for the Minnesota Surveyors' and Engineers' Society, it was moved by Mr. Claussen that a committee of three be appointed to take this matter up with the Minnesota Society. Messrs. Wolff, Jurgensen and King were subsequently appointed as this committee.

A motion was made by Mr. King that, inasmuch as there was a surplus from the banquet fund remaining in the treasury, those who had contributed to this fund be credited pro rata as their contributions with this surplus. The Treasurer thought the Society was in a position to use this surplus to good advantage for its benefit, and in this he was sustained by a majority of those present, the motion being lost.

Balloting for members came next in order. The names of Ralph Budd, chief engineer of the Great Northern Railway; E. E. Johnson, manufacturer of deep-well screens; and W. W. Hawley, assistant engineer with T. M. Fowble, were proposed for membership. Upon motion of Mr. Palmer, the Secretary was instructed to cast the ballot of the Society electing them to membership.

L. S. POMEROY, *Secretary.*

ST. PAUL, MINN., March 10, 1913.

CIVIL ENGINEERS' SOCIETY, ST. PAUL, MINN.

Gentlemen, — Your special committee appointed to investigate the feasibility of this Society's obtaining quarters in the new City Library Building wish to report that they have held one meeting, at the office of Mr. F. A. Fogg, president of the Library Board.

The matter was gone over very thoroughly with Mr. Fogg, the general outline of the proposition being the same as presented to this Society by the chairman of this committee at the last meeting, viz., that the Library Board permit the Civil Engineers' Society of St. Paul to occupy a room in the new library building with their library, the room to be used being one approximately 52 ft. by 20 ft. and known as the Technical Library Room.

Also, that this Society be permitted to hold its monthly lectures in this library room or in the small auditorium room of the library.

Also, that arrangements be made whereby the library belonging to this Society would be used only as a reference library by the general public, but that books could be taken out by members of this Society.

Mr. Fogg expressed himself as being thoroughly in harmony with the idea, but stated that as the Library Board will go out of existence when the new charter goes into effect, and as the new library will not be completed at that time, but will be completed under the jurisdiction of the new commissioner of education, the present library board could not make definite arrangements with this Society. It was the belief of the president of the board that such an arrangement could be carried out with the new commissioner of education.

It is the opinion of the committee that this question is one of great importance to the future of the Society. They are further of the opinion that a fund collected by this Society and presented to the city to go towards this new library might be rewarded by naming this room, which the Society desires the use of, " The Civil Engineers' Society Room."

The committee submits the above report with the request that it be accepted and the committee discharged, or, if it is the wish of the Society that it continue, that the Society will so express its wishes with instructions.

Respectfully submitted,

GEO. H. HERROLD, *Chairman*,
O. PALMER,
J. F. DRUAR,
Committee.

REPORT ON BANQUET OF FEBRUARY 12, 1913, GIVEN TO THE MINNESOTA SURVEYORS' AND ENGINEERS' SOCIETY.

Tickets sold to members attending	43
Tickets sold to members not attending	2
Tickets sold to members for non-members	2
Tickets sold to non-members	9
Total number of tickets sold	56
Total attendance at banquet	129

Financial.

Amount subscribed by 51 members		$275.50
Amount subscribed by non-members:		
Bausch & Lomb	$10.00	
W. & L. E. Gurley	10.00	
Eugene Dietzgen	5.00	25.00
		$300.50
Tickets sold to members, 47 at $1.50	$70.50	
Tickets sold to non-members, 9 at $1.50	13.50	84.00
Total subscriptions and tickets		$384.50

Expenditures.

For 129 plates, at $1.25	$161.25	
Cigars and other extras	47.40	
Orchestra	39.00	
Quartet and monologist	50.00	
Programs and menus	18.00	
Flowers and decorations	11.25	
Printing tickets	1.75	
Postage	2.10	
Miscellaneous	1.90	332.65
Balance		$51.85
Collected to date from subscriptions		$282.00
Collected to date from tickets		51.00
Total		$333.00

L. P. WOLFF, *Chairman*,
G. H. HERROLD,
W. E. KING,
Committee on Arrangements.

Montana Society of Engineers.

BUTTE, MONT., FEBRUARY 8, 1913. — The Society was called to order at the usual hour by President Robert A. McArthur. Members present, Messrs. Feeney, McArthur, Moore, Bowman and Simons. Minutes read and approved. Robt. A. Ricketts was elected to active membership in the Society. The Committee on Nomination of Officers for the coming year made the following report, which was adopted, to wit:

President — John H. Klepinger, of Great Falls.

First Vice-President — Reno H. Sales, of Butte.

Second Vice-President — Martin H. Gerry, Jr., of Helena.

Secretary — Clinton H. Moore, of Butte.

Treasurer — Samuel Barker, Jr., of Butte.

Trustee for Three Years — Harry H. Cochrane, of Butte.

By vote the Secretary was instructed to drop from the Year Book the names of all corresponding members who do not furnish him with their addresses within a reasonable time.

Adjournment.

CLINTON H. MOORE, *Secretary.*

Technical Society of the Pacific Coast.

REGULAR meeting held January 17, 1913, in the Board Room of the Mechanics Institute.

The meeting was called for the purpose of considering the best means of increasing the utility of the technical library of the Mechanics Institute.

President Loren E. Hunt called the meeting to order, and the Secretary made an opening statement, explaining the purpose of the meeting. A discussion then took place, during which the views of a number of members as to the best method of creating an engineers' library were fully expressed.

Mr. F. B. Graves, the librarian of the Mechanics Institute, entered into the discussion, and stated that any suggestion from any one would be welcomed. It was his desire to ascertain just what books and literature the engineer required at the present time to make a library which is of special value to him.

At the conclusion of the discussion a motion was made to appoint a committee of three, to take up this subject of an engineering library in San Francisco, and to report back to the Society within a reasonable time.

The President stated that he would take the choice of this committee under advisement.

The Treasurer, Mr. E. T. Schild, submitted his annual report as follows:

REPORT OF THE TREASURER FOR THE YEAR 1912.

1912.			
January 10.	Cash in bank	$776.14	
January 10.	Cash on hand	6.00	
			$782.14
	Received during the year 1912		597.59
			$1 379.73

December 31.	Expended during the year 1912	$630.48	
	Cash in bank	749.25	
			$1 379.73

RECEIPTS IN 1912.

1912.			
January 10.	Cash in bank	$776.14	
	Cash on hand	6.00	
	Dues collected	502.59	
	Three admission fees	15.00	
	Tickets for the Dickie dinner	80.00	
			$1 379.73

EXPENDITURES IN 1912.

	Four assessments to the Association of Engineering Societies	$231.88	
	Salary of Secretary, twelve months	180.00	
	Collection and office work	40.00	
	Postage, envelopes, etc.	39.45	
	Printing, stationery and typewriting	43.15	
	Total expenditures in connection with the Dickie banquet	87.50	
	Admissions to Mechanics Institute	3.50	
	Dues to scientific organizations	5.00	
1912.			$630.48
December 31.	Cash in bank, December 31, 1912		749.25
			$1 379.73

The report was submitted to the Board of Directors for approval.

The following Nominating Committee was appointed to select a list of officers for the ensuing year, and the Secretary was instructed to communicate with these members and to notify them of their appointment:

Messrs. C. E. Grunsky (chairman), Harry Larkin, Hermann Barth, George F. Day and Heinrich Homberger.

A meeting and banquet will be held in March, when the ballots for the new officers will be opened.

No further business requiring attention, the meeting adjourned.

Otto von Geldern, *Secretary.*

Louisiana Engineering Society.

Regular Meeting of the Society, February 10, 1913. — The meeting was called to order with President Shaw in the chair and 42 members and guests present.

The minutes of the meeting of January 20 were read and approved.

There being no business to come before the meeting, the technical exercises of the evening were held. These consisted of a very interesting and instructive paper by Mr. Warren B. Reed on the Intercostal Canal. After some little discussion on the paper, a vote of thanks was tendered Mr. Reed.

There being nothing further to come before the meeting, the same was adjourned to the usual collation.

James M. Robert, *Secretary.*

Oregon Society of Engineers.

PORTLAND, ORE., JANUARY 16, 1913. — A regular meeting of Oregon Society of Engineers was held at 247½ Stark Street, Portland, Ore., on Thursday, January 16, 1913, at eight o'clock P.M.

President D. C. Henny presided, and about 60 members and guests were present.

Mr. John H. Lewis, state engineer, addressed the meeting on the subject of "Oregon Water Resources; Their Development and Use," dealing particularly with the water resources of the state and the proposed hydro-electric plant at Celilo Falls on the Columbia River.

Mr. L. F. Harza took up the design and equipment of the proposed hydro-electric plant at Celilo Falls, and a discussion of the subject followed.

Mr. O. Laurgaard introduced the following resolution, which was unanimously adopted by the Society:

"*Whereas*, there are large opportunities in Oregon for irrigation and water-power development which are lying dormant for lack of definite information; and

"*Whereas*, private capital appears to be unwilling to risk the expenditures necessary to obtain this information; and

"*Whereas*, these opportunities represent assets to the state and its people, the value thereof should be ascertained at the earliest possible date to encourage development; and

"*Whereas*, the Deschutes basin offers very large opportunities for additional irrigation, and the Columbia River for power development; therefore

"*Be it resolved*, that it is the sense of the Oregon Society of Engineers that the state of Oregon undertake the study of said projects with a view to interesting private capital or to the construction under state auspices, and that the necessary funds be appropriated therefor conditioned upon expenditures being made a lien on the projects through water withdrawals, to the end that such funds be returned to the state treasury and be made available for further similar investigations."

The report of the Committee on Revision of Constitution was read and adopted.

The report of the Nominating Committee was read and adopted.

The report of the Membership Committee was read.

A letter was read regarding the selection of an architect for the Oregon State Building at the Panama Pacific Exposition, and upon motion of Mr. Graves, seconded by Mr. Schuchart, the matter was referred to the Executive Board with power to act.

Adjourned.

F. A. NARAMORE, *Secretary*.

PORTLAND, ORE., FEBRUARY 3, 1913. — A special meeting of the Oregon Society of Engineers was called at the request of three members of the Executive Board, to consider the endorsement by the Society of a bill proposed to be introduced in the state legislature providing for the regulation of the practice of civil engineering and surveying in the state of Oregon, and for the purpose of considering a proposed bill providing for the regulation and licensing of electrical contractors in the state; and was held at No. 247½ Stark Street, Portland, Ore., on Monday, February 3, 1913, at eight o'clock P.M.

In the absence of the President and Vice-Presidents, Mr. Walter H. Graves was elected temporary chairman.

Thirteen members were present.

As there was no quorum present, the only action the meeting could take was to discuss these measures. It was moved by Mr. Monteith, seconded by Mr. Stanley and carried, that a committee of one member from each branch of the engineering profession represented in the Society be appointed by the President to act as a legislative committee, and to take up the matter of licensing all engineers; and also for the consideration of such bills affecting the practice in the state.

As much time was consumed in the discussion and consideration of the proposed bill for licensing engineers, consideration of the proposed bill to license electrical contractors was deferred to a later date.

Meeting adjourned.

F. A. Naramore, *Secretary.*

Portland, Ore., February 13, 1913. — The annual dinner and business meeting of Oregon Society of Engineers was held on Thursday, February 13, 1913, at 6.30 p.m., in the dining rooms of the Commercial Club, Portland, Ore.

In the absence of the President, Vice-President Wm. S. Turner presided, and there were present eighty men, including members of the Society and their guests.

The address of President D. C. Henny was read by the Secretary. Mr. Naramore then read his annual report as Secretary, which was followed by a reading of the Treasurer's report by Mr. Blood.

The report of the tellers was read by Mr. Loring, chairman of the tellers, showing the election of the following officers for the ensuing year:

President — Walter H. Graves.

Vice President, term expiring 1914 — John H. Lewis.

Vice-President, term expiring 1916 — W. H. Crawford.

Secretary — O. E. Stanley.

Treasurer — Henry Blood.

Directors:

Term expiring 1914 — D. C. Henny, J. R. Townsend.

Term expiring 1916 — F. A. Naramore, Douglas W. Taylor, H. L. Vorse.

Nominating Committee — Fred A. Ballin, C. E. Condit, Robert S. Edwards, Louis C. Kelsey, E. B. Newcomb, Frederick Powell, Lewis I. Thompson, Fred D. Weber.

Mr. Graves, the new President, was called upon for a speech, and responded.

Mr. Kinder, president of the Progressive Business Men's Club, offered the suggestion that engineers could help in many ways in forming public opinion by taking a more active part of social life.

Upon motion of Mr. Loring, seconded by Mr. Crawford, the Constitution was amended in the following particulars:

Section 6 of Article VIII will now read as follows: "Members six months in arrears shall lose their voting privilege, and twelve months in arrears shall automatically cease to be members."

Section 3 of Article XII will now read as follows: "At any business meeting the presence of ten per cent. of the total enrolled active membership of the Society shall constitute a quorum."

Article XIV shall read as follows: "*Section 1.* Amendments to this

Constitution may be made by an affirmative vote of two thirds of the members in good standing present at any regular meeting of the Society provided that notice of any proposed amendment shall have been presented in writing at the previous regular meeting; or by an affirmative vote of two thirds of the members in good standing voting upon a letter ballot issued by direction of the Executive Board, notice of the amendment having been given in writing at the previous regular meeting of the Society."

Moved by Mr. Bullington, seconded by Mr. Loring and carried, that the Society give a vote of thanks to the retiring officers.

A letter from the Oregon Electrical Contractors Association relating to the licensing of electrical contractors in the state was read, and Mr. Vorse moved its adoption. Mr. Dieck moved to amend by referring the matter to the Executive Board for action. Amendment seconded by Mr. Loring and carried.

Mr. Morton, chairman of the Library Committee, reported that the the Librarian had completed a catalogue of the books on engineering in the Public Library, copies of which could be had on request. He exhibited a print of the plan of the Library building, showing the location of the technical room.

Mr. Graves moved that a vote of thanks be sent to Miss Rockwood, the Librarian, for the work she had done in compiling the catalogue of technical books. Seconded by Mr. Vorse and carried.

Mr. H. B. Hastings suggested the appointment of a committee to investigate engineering disasters, and cited several instances where structures had failed, some causing loss of life, upon which no engineering body had given an opinion.

Mr. Blood commented upon Mr. Hastings' remarks, and endorsed the suggestion that engineers take a more active interest in ascertaining the causes for the failure of engineering structures.

Mr. Morton suggested the appointment of a legislative committee and the enactment of a law controlling contracting engineers.

Mr. Ellis F. Lawrence spoke of the work of the Greater Portland Plans Association, and the part that engineers can take in the civic club.

Mr. Stanley inquired about the society emblem, and was told that the Executive Board would decide the question.

Mr. Dieck called attention to the fact that the technical courses of the state schools were determined by the Board of Higher Curricula, upon which board there were no technical men; and moved that the Executive Board be instructed to communicate with the governor and request that he appoint an engineer on the Board of Higher Curricula. Seconded by Mr. Vorse and carried.

Moved by Mr. Stanley that the President appoint a legislative committee comsisting of five members, to be selected from five different branches of engineering represented in the Society. Seconded by Mr. Vorse and carried.

Moved by Mr. Dieck that a committee of three be appointed to care for questions of "The Relation of the Engineering Profession to the Public," except such matters as shall be cared for by the Legislative Committee in dealing with the legislative bodies of the city and state. Seconded by Mr. Fouilhoux and carried.

Mr. Calef spoke of the work of the Oregon Manufacturers' Association, and urged that engineers use their influence in favor of "Made in Oregon" products.

Mr. Blood suggested that several technical journals be subscribed for, to be left at the club rooms.

Adjourned.

F. A. Naramore, *Secretary.*

Report of the Secretary, February 13, 1913.

The actions of the Secretary as an officer of the Society are made evident more or less to the members during the year through announcements and meetings, and I shall therefore make this report as brief as is consistent with the requirements of the occasion.

Mr. J. C. Stevens, who was elected Secretary at the last annual meeting, resigned in March to take a position in Barcelona, Spain, with the Pearson Engineering Corporation. Mr. Stevens' work as Secretary did much to build up the Society and increase its efficiency, and it was with much regret that his resignation as Secretary of the Society was received.

During the year several changes have taken place in the personnel of the Executive Board and officers of the Society. Mr. Ralph Budd was elected Vice-President, to fill the vacancy caused by the death of Mr. C. B. Smith; and, owing to change of residence, the resignations of Mr. Powell and Mr. Honeyman were received. To fill these three vacancies, Messrs. John H. Lewis, H. L. Vorse and O. E. Stanley were elected members of the Executive Board. Upon Mr. Stevens' resignation, the present Secretary was appointed, necessitating his resignation as Treasurer, and Mr. Gordon Kribs was appointed to that office; but he resigned in November to take up work in Texas, and Mr. Henry Blood was appointed as Treasurer of the Society.

In his report of last year, Mr. Stevens pointed out the necessity of securing a regular meeting place for the Society, which necessity became more and more apparent; and the desirability of establishing an employment bureau for the benefit of the members of the Society. These two features of the Society's activities have now been realized, the first by coöperation with the Portland Architectural Club, through the Oregon Technical Club; and the second by the appointment of Mr. Stanley as secretary of the employment bureau. The working of the employment bureau will be explained more in detail by Mr. Stanley. It is hoped that the coöperation of the Architectural Club with this Society in the formation of the Oregon Technical Club will do much to increase the interest of the members in the Society. The Oregon Technical Club is, in a way, a holding body, managed by a board of five governors, two of them being members from the Oregon Society, two from the Architectural Club, and the fifth being chosen by these four. Great benefit to the profession would no doubt accrue if all the engineering and technical societies of the city would make similar arrangements for quarters, so that all such societies in the city would have a common meeting place.

The membership during the year 1912 was less than that of last year, due perhaps to the lax immigration laws which existed at the time of the formation of the Society, and the return of many to their native land. The present membership is 163 active members, 18 junior members and 2 associates. Within the past week there have been admitted 18 active members and 18 juniors, these numbers not being included in the figures first given.

Based upon the fact that the Society is stronger and has a more stable

membership than it had a year ago, I firmly believe that the requirements for membership should be more rigidly adhered to than has been the case in the past, as this is a most effective method of encouraging the best men to take an active part in the " doings " of the Society.

The Executive Board has met frequently, as the affairs of the Society demanded.

The Society has held meetings at least once a month, except during the months of July, August and September, and at these meetings various subjects of interest to the engineer have been treated, papers being read and addresses given, the interest and value of which I need not enlarge upon. One of these was an address by Mr. Ralph Modjeski, on " Bridge Foundations in the Columbia and Willamette Rivers." Practically all of the papers have been published in the Society's official publication, the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

The standard of the papers and talks given before the Society is high. Mr. Hegardt's paper occupied an entire issue of the JOURNAL recently, and the paper read by Mr. Vorse was quoted in the *Engineering News.*

The Secretary and the Chairman of the Program or Entertainment Committee would, I am sure, be glad to learn from members in possession of such information, of the coming to the city of any of the well-known engineers of the country, so that arrangements might be made, if possible, to secure a paper or a talk from the visiting engineer. As you all know, the papers published in the JOURNAL receive national circulation, and this should encourage the members of the Society to prepare and present some valuable papers.

During the shifting around of the officers of the Society, several applications for membership were mislaid or lost, and if any member present is aware of the identity of the applicant, the Secretary would be glad to be advised, so that blanks may again be sent to these applicants.

In retiring as Secretary I wish to thank the Executive Board and the members of the Society for the hearty coöperation received, and bespeak for my successor a like coöperation.

F. A. NARAMORE.

EXECUTIVE BOARD.

JANUARY 13, 1913. — A meeting of the Executive Board of Oregon Society of Engineers was held on Monday, January 13, 1913, at 12.15 P.M., at the Oregon Grill.

Present, D. C. Henny, W. S. Turner, A. D. Montague, F. P. Rawson, H. L. Vorse, O. E. Stanley, Henry Blood and F. A. Naramore.

Moved by Mr. Vorse that the names of J. A. Fouilhoux, Henry Blood, and F. A. Naramore be submitted to the mayor of the city of Portland, as members of the Oregon Society of Engineers who would be willing to serve on a committee to revise the building code. Seconded by Mr. Turner and carried.

Bills were ordered paid.

Report of Nominating Committee was received. Upon a reading of the same, and some discussion, report was referred back to the committee for further action, with request that report be again submitted before the regular meeting of the Society on the 16th.

Adjourned.

F. A. NARAMORE, *Secretary.*

JANUARY 28, 1913. — A special meeting of the Executive Board of Oregon Society of Engineers was held on Tuesday, January 28, 1913, at 1.30 P.M., at the Portland Hotel, immediately following the joint luncheon of the technical societies.

Present, Messrs. Turner, Morton, Schuchart, Vorse, Stanley, Blood and Naramore.

Meeting was called to order by Mr. Turner, who presided.

Moved by Mr. Vorse, that it is the sense of the Executive Board that the passage of the proposed bill providing for the licensing of electrical contractors is a necessity and is hereby heartily endorsed. Seconded by Mr. Schuchart and carried. But the Executive Board decided that it could not express the opinion of the whole Society on the matter, and therefore the same was referred for consideration by the special meeting of the Society called for February 3.

Letter of H. N. Lawrie was read, regarding House Bill 205, which proposes to create a Bureau of Mines and Geology in the state of Oregon; and this matter was also referred to the Society for consideration at the meeting called for February 3.

Committee of two was appointed to audit the books of the Treasurer before the annual meeting.

Bills ordered paid.

Adjourned.

F. A. NARAMORE, *Secretary.*

FEBRUARY 13, 1913. — A regular meeting of the Executive Board of Oregon Society of Engineers was held in the Green Room of Commercial Club, Portland, Ore., at 6.15 P.M., on Thursday, February 13, 1913.

Present, Messrs. Turner (presiding), Vorse, Naramore, Blood, Morton, Schuchart and Stanley.

The report of the tellers was presented by the chairman, Mr. David Lorning, showing the election of the following officers:

President — Walter H. Graves.

Vice President — John H. Lewis (term expiring 1914).

Vice President — W. H. Crawford (term expiring 1916).

Secretary — O. E. Stanley.

Treasurer — Henry Blood.

Directors — D. C. Henny, J. R. Townsend, term expiring 1914; F. A. Naramore, D. W. Taylor, H. L. Vorse, term expiring 1916.

Nominating Committee — Fred A. Ballin, C. E. Condit, Robt. S. Edwards, Louis C. Kelsey, E. B. Newcomb, Lewis I. Thompson, Fred D. Weber, Frederick Powell.

The report was accepted by the Executive Board, which then adjourned.

F. A. NARAMORE, *Secretary.*

FEBRUARY 19, 1913. — A special meeting of the Executive Board of Oregon Society of Engineers was held on Wednesday, February 19, 1913, at 1.30 P.M., in the Governors' Room of Commercial Club, Portland, Ore.

The meeting was called to order by the President. There were present Messrs. Graves (presiding), Turner, Taylor, Vorse, Blood, Crawford, Townsend and Stanley.

Moved by Mr. Vorse, seconded by Mr. Blood, that the Executive Board adopt the following resolution:

"The Columbia River Power Project near The Dalles, Ore., as proposed by the state engineer, was thoroughly considered and endorsed by the Oregon Society of Engineers at a well-attended meeting on January 16, 1913.

"We believe that a thorough investigation will prove that the plan is not only feasible, but practicable from every standpoint. The magnitude of the undertaking is the only unusual feature involved. Owing to the great benefits which will come to the entire Northwest through the early completion of the project by either private or public funds, we wish at this time to urge upon the legislature the importance of appropriating sufficient money to make a thorough investigation of the project.

"We believe that this investigation can be carried out to better advantage by the state engineer than by turning the same over to a non-technical board, as recently proposed in a bill which has passed the State Senate. This bill should be amended to conform with the bill approved by the joint legislative committee";

that a copy thereof be sent to Mr. Lewis (State Engineer), a copy to each member of the State Legislature, and that copies be also furnished to the local press. Carried.

Mr. Vorse agreed to take the copy to Mr. Lewis at Salem, and Mr. Crawford said he would see that the newspapers were furnished copies.

Bills were presented, audited and ordered paid.

Moved by Mr. Turner, seconded by Mr. Taylor, that the meetings of the Executive Board be held monthly, on the second Wednesday of each month, at 12.15 P.M., at the Commercial Club. Carried.

Moved by Mr. Crawford, seconded by Mr. Taylor, that Mr. Turner be appointed chairman of a committee, with power to select two additional members, to make the necessary arrangements for handling the matter of subscriptions to the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES. Carried.

Adjourned.

ORRIN E. STANLEY, *Secretary*.

Association
OF
Engineering Societies

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PROCEEDINGS.

Engineers' Club of St. Louis.

The 732d meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, January 15, at 8.30 P.M., President Hunter presiding. There were present 63 members and 33 visitors.

The minutes of the 730th and 731st meetings of the Club were read and approved, and report of 523d, 524th, 525th and 526th Executive Committee meetings was made to the members.

A letter of invitation from the local section of the A. I. E. E. to attend a formal dance on January 25 was read, and on motion of Mr. Schuyler a motion of thanks was tendered the A. I. E. E., and all members were urged to attend the dance.

Mr. W. E. Bryan was elected member of the Board of Managers of the Association of Engineering Societies to succeed Mr. E. B. Fay, resigned.

Mr. H. H. Humphrey presented a paper on the " Mechanical and Electrical Equipment of the Railway Exchange Building," describing the heating, ventilating, lighting, telephone, elevator and conveyor systems being installed in that building. A general discussion followed.

Col. E. D. Meier spoke on the needs of a great industrial museum in America and urged the membership to work for such a project.

Mr. Toensfeldt presented informally a tentative plan for the new club house, which gave rise to discussion and criticism and a general suggestion that the house should be on a larger scale than the plans show. The President was authorized to appoint a committee to place the matter of financing the building before the business men of St. Louis.

Adjourned.

W. W. Horner, *Secretary.*

The 733d meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday, February 5, at 8.15 P.M., as a joint meeting under the auspices of the A. S. M. E. There were 29 members and 13 visitors present.

President Hunter resigned the chair to Chairman Ohle of the A. S. M. E., who presided during the presentation by Prof. A. L. Westcott of an illustrated paper on "Lubricating Properties and Other Characteristics of Cup Greases."

Adjourned 10.00 P.M.

W. W. HORNER, *Secretary.*

THE 734th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, February 19, 1913, President Hunter presiding. There were present 39 members and 14 visitors.

Minutes of the 732d and 733d meetings of the Club were read and approved, and the minutes of the 527th and 528th meetings of the Executive Committee were read.

Following a recommendation of the Executive Committee, Mr. Greensfelder moved that the Chair appoint a committee of three to see that the engineering profession be properly represented on the new Board of Freeholders. Motion was seconded and carried.

Mr. W. A. Hoffman, inspector of boilers and elevators, presented an illustrated paper on "Smoke Abatement."

Mr. E. H. Tenney presented a written discussion and several other members spoke informally. Prof. George Moore, of Washington University, spoke of the effect of smoke and fumes on plant life.

Adjourned 10.30 P.M.

W. W. HORNER, *Secretary.*

THE 735th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, March 5, 1913, as a joint meeting with the St. Louis Association of Members of the American Society of Civil Engineers.

There were present 52 members and 19 visitors.

The meeting was called to order by President Hunter, who stated that the reading of the minutes and all other routine business would be dispensed with. Mr. Childs introduced the following resolution and moved its adoption:

"*Whereas*, a recent law of the state of Missouri provides for a Public Service Commission to consist of five commissioners to be appointed by the governor, and, as the duties of the said commission will be mainly the regulation and control of public service corporations and public utilities, it is important that the commission shall include in its membership a man educated and experienced in engineering work.

"The construction, maintenance and, to a large extent, the operation of public utilities is engineering work and under the direction of experienced and able engineers, and the Public Service Commission, in exercising regulation and control over these utilities and corporations, should be provided with members particularly fitted with education and experience to understand the complicated questions of construction, maintenance and operation involved.

"*Therefore, be it resolved*, by the Engineers' Club of St. Louis, Mo., that we believe the best interests of the state will be served by including in the membership of the Public Service Commission an engineer to act as adviser in the engineering questions involved;

"*And be it further resolved*, that the President of the Engineers' Club appoint a committee of three to present a copy of this resolution to Hon. Elliott W. Major, governor of the state of Missouri, and respectfully urge upon him due consideration of the same."

Motion seconded by Mr. Greensfelder. Mr. Hawkins moved that the resolution be amended by changing the words, "an engineer" to "one or more engineers"; seconded by Mr. Woermann. The resolution as amended was adopted unanimously.

Mr. Hunter resigned the chair to Mr. Woermann for the A. S. C. E., who introduced the speaker, Mr. John H. Gundlach, president of the City Council and vice-president of the City Plan Commission. Mr. Gundlach's talk on city planning was illustrated by views and plans of St. Louis and of other cities. Messrs. Baxter, Brown, Langsdorf and Greensfelder participated in the discussion; at the conclusion of the discussion a vote of thanks was tendered Mr. Gundlach. The meeting then adjourned to the library where a supper was served.

Adjourned.

W. W. HORNER, *Secretary.*

President Hunter subsequently appointed as the committee authorized by the above resolutions, Messrs. Phillips, Laird and Garrett.

THE 736th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, March 19, at 8.30 P.M., as a joint meeting with the St. Louis section of the A. S. M. E.

The total attendance was 123. President Hunter called on Chairman Ohle of the A. S. M. E. to preside.

Prof. William Kent, A.M., M.E., consulting engineer, editor of the *Engineering Digest* and author of the "Mechanical Engineer's Pocket Book," gave an address on "Engineering and Common Sense."

After the meeting refreshments were served in the library.

Adjourned.

W. W. HORNER, *Secretary.*

THE 737th meeting of the Engineers' Club was held at the Club rooms, at 3817 Olive Street, on Wednesday evening, April 2, at 8.30 P.M., as a joint meeting with the St. Louis Section, A. I. E. E. The total attendance was 97. President Hunter called the meeting to order.

The Secretary read a letter of resignation from Mr. H. M. Cryder as Librarian of the Club. It was moved and seconded that the resignation be accepted and the Club proceed to elect a new Librarian. Prof. Geo. W. Lamke was elected Librarian for the remainder of 1913. President Hunter then turned the meeting over to Chairman Osborn, of the local section of the A. I. E. E.

Prof. A. S. Langsdorf presented a paper on "Surges and Oscillations in High Potential Circuits."

The paper was exceptionally interesting and entirely within the comprehension of the average engineer.

After the meeting refreshments were served by the A. I. E. E.

Adjourned.

W. W. HORNER, *Secretary.*

Boston Society of Civil Engineers.

BOSTON, MASS., MARCH 19, 1913. — The sixty-fifth annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, 9 Beacon Street, Boston, at 12.30 o'clock P.M., President James W. Rollins in the chair.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grades named:

Members — Walter W. Clifford and Samuel P. Waldron.

Juniors — Walter A. Ford, Frank W. Johnson, Laurence K. Marshall, William J. Power, Jr., and Leslie P. Reed.

By a unanimous vote the following amendment to the By-Laws, passed at the last meeting, was again passed, as required by the By-Laws: Amend by-law 7 by adding at the end of the second paragraph the following words: "Applicants who may be so situated as not to be personally known to four members may be recommended by three members of the Board of Government."

The Secretary read the annual report of the Board of Government, and by vote it was accepted and placed on file.

The Treasurer read his annual report, and by vote it was accepted and placed on file.

The Secretary read his annual report, and by vote it was also accepted and placed on file.

Mr. Charles R. Gow, for the Committee on Excursions, read the annual report of that committee, which was accepted and placed on file.

The recommendation of the committee, "That the practice of maintaining a permanent excursion committee be abolished, and that the duties previously assigned to such a committee be delegated to the Board of Government, to be exercised at its discretion," was referred to the Board of Government with full powers.

The Librarian read the annual report of the Committee on the Library, and by vote it was accepted and placed on file. The recommendation made by the committee in relation to an appropriation for the purchase of current engineering books was by vote referred to the Board of Government with full powers.

On motion duly made and seconded, it was voted to refer to the Board of Government the question of appointing the special committees of the Society, with full power to act.

Mr. Desmond FitzGerald, the committee appointed to prepare memoir of our late associate Francis Blake, read his report, which was accepted.

The tellers of election, appointed by the President, Messrs. N. S. Brock and J. L. Howard, submitted their report giving the result of the letter ballot.

In accordance with this report the President announced that the following officers had been elected:

President — Frederic H. Fay.
Vice-President (for two years) — Charles R. Gow.
Secretary — S. Everett Tinkham.
Treasurer — Charles W. Sherman.
Directors (for two years) — Charles B. Breed and John N. Ferguson.

The President then presented, in the name of the Society, the Desmond FitzGerald Medal for the year 1912 to Charles Thomas Main, for his paper entitled, "The Work, Aim and Conduct of the Engineer." Mr. Main in accepting the medal expressed his deep appreciation of the honor conferred upon him in the award of the medal. He also referred to the suggestion made in the paper which had brought him this medal, and which had resulted in this Society adopting a code of ethics, which code is substantially the same as adopted later by several of the national engineering societies.

On motion of Mr. Worcester, it was voted to print one thousand copies of the Code of Ethics adopted by the Society December 18, 1912.

The retiring President, Mr. James W. Rollins, then delivered the following address:

The year past of our Society has shown a most satisfactory progress in all ways. Our membership in all classes is to-day 823, the average attendance at our meetings has been 175, both of which figures exceed all previous records; while from a financial standpoint (our balance for the year being over $600) the results are most satisfactory; the above figures all showing a reasonable growth in strength, also an increasing interest in our work and meetings.

The meetings during the year have been in a way unusual, in that very few strictly technical papers have been presented; and it is an open question whether this fact is not responsible for the increased attendance. And this again brings up the question as to the advisability of presenting (if you are fortunate enough to find a member to prepare) technical papers to be *read* at the meetings; or whether it would be better to have these papers printed and distributed to members, and have discussions only. The experience of the American Society on this matter favors the latter course, and we look forward to the time when we can print our own papers, discuss them in open meetings, and finally have all printed and bound for reference.

We have had several distinguished guests during the year, — Colonel Goethals, chief engineer of the Panama Canal Commission; the foreign representatives to the Navigation Congress; Colonel Cooper, chief engineer of the Mississippi Power Company; and Mr. George A. Harwood, chief engineer of the Electric Zone Improvements and Grand Central Station work for the New York Central Railroad in New York. To hear of and see on the screen the works done by these men was most instructive, interesting and broadening and should make us realize that all the great things are not done in Boston or by members of our Society.

For many years we have been working, and, according to our worthy Secretary, scrimping, to provide new quarters for our Society. We have had several joint meetings with other engineering societies, to get up enthusiasm on the question of an engineers' club. The first proposition advanced was too ambitious, and was abandoned. Last year a new scheme was developed and ended in the incorporation of the Engineers Club, largely by members of our Society, the leasing of a site and construction of a clubhouse on Commonwealth Avenue and Arlington Street. Our Society, deeming the accommodations inadequate for our needs, declined the invitation to lease quarters in this clubhouse. On account of the great interest in this club, the house being opened with a waiting list of one hundred, it was probably a wise move on the part of the Boston Society to remain in its old quarters, enlarged and refitted and made more attractive, to better accommodate our growing needs.

It is reported that since making these improvements the attendance of

members is steadily growing, and the experiment of encroaching on the precious Permanent Fund for the necessities of life will be entirely justified.

This element of comradeship and sociability is again proven "good," after having been started by our entertaining and not technical meetings of the year. The speaker is of the opinion that most men like to get together socially, to talk shop a little, to hear of the other fellow's troubles and woes, to see pictures of new and great works, and to hear them described; and to leave uninteresting though most valuable technical matters to be presented, — read over and studied at leisure or filed away for future reference.

It is a self-evident fact to-day that what is needed most in all walks of life, except possibly in law, is *coöperation*, — getting together men with men, discussing issues fairly and honestly, coming to a decision that is just to all, and then going ahead and "doing things."

It is easy to tear down any structure, to find fault with corporations, individuals or public officials, but these would-be destroyers and critics seldom offer any solutions to the problems that great men struggle with.

Any organization which brings together men of different stations in life, different interests, education, even of different religion and politics, helps to solve this question of "how to get together."

The Engineers Club is a good example of this, having in its membership not only engineers of all kinds, but all kinds of men who work with engineers or hope some day to work with them, — engineers, railway managers, lawyers, bankers and merchants, — all recognizing the worth of engineering, — getting together, learning to know each other, and each other's works and aims in life. It's all in the "view-point," and the great thing to do is to try to see the point from which the other fellow looks at our problems.

Great things are done by coöperation between engineers and contractors, and most successfully and happily when each can see the other man's point of view.

The great success of the work at Panama is due to the coöperation and loyalty of all the men on that work, from the Jamaica negroes to the engineering force. Each one of these men, inspired by the worth and work of their leader, Colonel Goethals, thinks the success of the work is due to his own efforts, and the result has been the greatest efficiency work of the century.

The Catskill Aqueduct work in New York has also been another great example. Although some contractors have lost money, not one complains of the engineering force, and that force swear by their leaders and their chief, and they have together accomplished a work with great difficulties, but with no failures and few delays.

The United States Government tried for five years to build a dry dock in Brooklyn at an expense of half a million dollars and the failure of two contractors.

Having war ships nearly finished but with no dry dock in the country large enough to dock them, they cut loose from the usual Government "red tape," asked privately for bids based on contractors' own plans as to method of doing the work, and awarded the contract to the lowest bidder.

The engineers and contractors joined their forces and energies, worked together in entire harmony and for one end to complete the work. Problems new and problems difficult were worked out together, and all with the result that the dock was completed eight months ahead of contract time, and with a reasonable profit to the contractor.

Under usual Government conditions and exactions, and with the usual

red tape, this work would without much doubt have gone into the history of previous dry docks, — failure or great loss to contractors; the dock completed months or years behind time.

About the same time, another dock was being rebuilt under usual Government conditions, engineers and red tape. There was no coöperation, the engineer insisted on every minor detail of specification; and the result was the old story, — a suit against the Government which will result in the payment of thousands of dollars to the contractor, all because of the lack of ability to coöperate.

Every year there is held in New York a contractors' dinner, and naturally it is a *real dinner*. Gathered about the tables as hosts are all the leading contractors of that great city; men, most of them engineers, having in hand contracts amounting to hundreds of millions of dollars. As their guests, are the leading engineers of New York, men who have planned and have in charge the execution of these great undertakings; also often some of the leading officials of the city.

It is a great pleasure for an outsider to be at this dinner — for the dinner is a good one — the Catskill Aqueduct's product not greatly in evidence; but the spirit of good fellowship which prevails between these contractors and engineers, who to-day are doing the greatest engineering works the world ever saw, shows that both sides are getting together, and makes true again the old proverb, that "in union there is strength"; and that, working together, the engineers and contractors of to-day can "make good" on any of the great construction problems of our modern civilization.

So we members of the Boston Society, if we are to do the work society expects of us, if we are to grow stronger as the years go by, must work together, learn to know each other better, make our meetings attractive, particularly to the young men, for some of us are gray and *bald-headed;* each year our ranks grow thinner, and the young men of to-day are to be the leaders of tomorrow.

Let us keep true the traditions of our great profession, but once in a while let us forget that we are *engineers*, and simply be men together, working out one with another some of the great problems of life of which we each must bear a share.

The President then introduced the President-elect, Mr. Frederic H. Fay, who said in part:

Sixty-five years ago, on the 15th of June, a small group of engineers met in Boston, organized the first society of engineers on the American continent and named the organization the Boston Society of Civil Engineers. Three years later, on April 24, 1851, the Society was incorporated by an act of the legislature. This was at a time when engineering as a profession was struggling to gain a foothold in this country, and among the early members of the Society were men who rose to national prominence in the profession.

Throughout its existence the Society has numbered in its ranks engineers of the highest standing, as has been fitting for the senior engineering society in America, and in looking over our membership list we find the names of seven past and present members who have held the office of president of the American Society of Civil Engineers, as well as others who have presided over the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers. This is indicative not only of the quality of our membership, but also of the breadth

of the Society. Our members are by no means confined to the field of civil engineering, in the modern narrow sense, but they come from all branches of the engineering profession, and perhaps it were more fitting if we were known as the Boston Society of Engineers.

But even the word " Boston " is of too limited application, for our 823 members are to be found, not alone in Boston or New England, but scattered all over the United States as well as in Canada, Central and South America, the West Indies, our American insular possessions and even as far away as South Africa.

Boston, more than any other center of the country, has been a producer of engineers — of men who have given, and are giving, good account of themselves in distant fields as well as at home.

To my mind, one of the reasons why so many capable engineers have grown up hereabouts is that our Society has been the means of bringing its younger members in contact with those older and more prominent in the profession; and that the latter have loyally supported the Society and given the younger men the benefit of their experience and advice. This feature has been accountable for much of the success of the Society in its sixty-five years of honorable existence, and it should become a still more important factor in the future. We need the counsel and friendly criticism of our older members, the men of wide experience. At the same time, we should have still more support from the younger men in carrying on the active work of the Society. With this coöperation, the Society will grow in strength and power and influence.

For myself I wish to express to you my deep appreciation of the honor of election to the presidency of the Society, and it is indeed a great honor to preside over the affairs of this, the senior of all the engineering societies of the country. When I think of the long list of distinguished engineers who have preceded me, consider the responsibilities of the office, and remember that a presidential address is to be prepared for delivery next March, I realize that the man who assumes the duties of president is undertaking no small contract.

However, I know that I may speak for the newly elected officers, and for those holding over, and assure you that during the coming year the Board of Government will use its best efforts to advance the interests and promote the welfare of the Society.

The members then adjourned to the auditorium of the City Club, where members and guests to the number of 145 sat down to the thirty-first annual dinner.

After the dinner, Mr. J. Waldo Smith, chief engineer Board of Water Supply of New York, gave a very interesting illustrated talk entitled, " Some Features of the Contracts, Specifications and Construction of the Catskill Water Supply for the City of New York."

In the evening a " Smoker " was held in the auditorium of the City Club, at which the attendance was about 250.

The gathering was of the same informal character as in former years, and in addition to music by an orchestra and songs by our members, we were favored by Mr. Albert H. Houghton, of Boston, with several songs finely rendered. Mr. William A. Murphy, of Boston, was also present and gave an address which was replete with good advice and witty stories.

S. E. Tinkham, *Secretary.*

Annual Report of the Board of Government for the Year 1912-13.

Boston, Mass., March 19, 1913.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the Constitution, the Board of Government submits its report for the year ending March 19, 1913.

At the last annual meeting the total membership of the Society was 806, of whom 742 were members of the Society, 21 juniors, 2 honorary members, 24 associates and 17 were members of the Sanitary Section only.

During the year the Society has lost a total of 41 members, 23 by resignation, 9 by forfeiture for non-payment of dues, and 9 have died.

There has been added to the Society during the year a total of 58 members of all grades; 57 have been elected and 1 reinstated.

The present membership of the Society consists of 2 honorary members, 754 members, 28 juniors, 23 associates and 16 members of the Sanitary Section only, making a total membership of 823, a net gain of 17.

The record of the deaths during the year is —

George I. Leland, died May 16, 1912.
J. Edwin Jones, died June 3, 1912.
Robert Leland Read, died June 5, 1912.
Charles R. Cutter, died July 30, 1912.
Theodore O. Barnard, died October 20, 1912.
George Albert Kimball, died December 3, 1912.
Charles A. Allen, died December 9, 1912.
Francis Blake, died January 19, 1913.
Albert S. Cheever, died February 17, 1913.

Ten regular meetings and one special meeting have been held during the year. The average attendance at the meetings was 175, as against 155 last year, the largest being 425 and the smallest 65.

The following papers and talks have been given at the meetings:

March 20, 1912. — Charles T. Main, "The Work, Aim and Conduct of the Engineer." John R. Freeman, "Water Supply of the City of Mexico." (Illustrated.)

May 10, 1912 (special students' meeting). — Leonard Metcalf, "Some Recent Developments in Sewage Purification Methods." (Illustrated.)

May 15, 1912. — Arthur W. Dean, "The Construction and Maintenance of State Roads in Massachusetts." Hugh L. Cooper, "Damming the Mississippi." (Illustrated.)

June 20, 1912. — Col. George W. Goethals, "Panama Canal." (Illustrated.)

September 18, 1912. — Clarence T. Fernald, "Notes on the Construction of the Charles River Bridge for the Boston Elevated Railway Company." (Illustrated.)

October 16, 1912 (joint meeting with the American Society of Mechanical Engineers and the American Institute of Electrical Engineers). — Hugh L. Cooper, "Description of the Water Power Development of the Mississippi River Power Company at Keokuk, Iowa." (Illustrated.) D. L. Galusha, "Description of the Main Electrical Features of the Plant at Keokuk, Iowa." (Illustrated.)

November 20, 1912. — Frank W. Hodgdon, "Some Incidents of Survey of Mountains Near the Boundary between Costa Rica and Panama." (Illustrated.)

December 18, 1912. — George A. Harwood, "The Construction of the New Grand Central Terminal for the New York Central & Hudson River Railroad Company." (Illustrated.)

January 22, 1913 (joint meeting with the American Society of Mechanical Engineers and the American Institute of Electrical Engineers). — William H. Lewis, "Hydraulics in City Building." (Illustrated.)

February 19, 1913. — Prof. Lewis E. Moore, "Small Bascule Highway Draw Span." Frederic H. Fay, "Some Notes on Highway Bridge Floors." Prof. Charles M. Spofford, "An Account of Some Early Experiments upon Reinforced Concrete." Joseph R. Worcester, "Initial Stress in Steel Section." (Illustrated.)

The Sanitary Section of the Society has had six meetings during the year, with an average attendance of fifty. The following subjects have been discussed at the meetings of the Section:

March 6, 1912. — Leonard Metcalf, "Some Sewage Disposal Plants in Germany."

November 27, 1912. — Langdon Pearse, "The Sanitary Work of the Sanitary District of Chicago."

December 4, 1912. — Dr. Rudolph Hering, "Refuse Disposal."

January 8, 1913. — Prof. R. C. Carpenter, "Ventilation."

February 5, 1913. — Glen D. Holmes, "The Intercepting Sewer and River Improvements at Syracuse, N. Y." William F. Williams, "The New Bedford, Mass., Intercepting and Outfall Sewer." David A. Hartwell, "The Fitchburg, Mass., Intercepting Sewer."

The Board of Government has adopted the recommendation of the committee appointed to award the Desmond FitzGerald Medal, and is pleased to announce that it will be given this year for the paper entitled, "The Work, Aim and Conduct of the Engineer," by Charles T. Main.

On May 10, 1912, the students in the Civil Engineering Courses at Harvard, Tufts and the Institute of Technology were for the second time the guests of the Society at a special meeting held at the Boston City Club. Mr. Leonard Metcalf gave an illustrated talk on "Some Recent Developments in Sewage Purification Methods." The attendance was about 275.

The holding of joint meetings with the members of the American Society of Mechanical Engineers and of the Boston Section of the American Institute of Electrical Engineers was continued the past year. The Mechanical Engineers conducted the literary exercises at the close of our regular October meeting, and at our regular meeting in January the Mechanical and Electrical Engineers met with us.

The Society took advantage of the presence in Boston of the delegates and members of the Twelfth International Congress of Navigation and tendered them a reception, which was held in the banquet hall of the Boston City Club on the evening of June 6, 1912, at six o'clock. The occasion afforded the members of the Society an opportunity to meet these distinguished foreign engineers and to extend to them a cordial welcome. As only an hour was allowed for this function, it was necessary to make the reception very informal, but it was thoroughly appreciated by those of our members who were able to be present, and it was apparently enjoyed by our guests.

At the December meeting the Society adopted a code of ethics prepared by a committee of the Society authorized at the last annual meeting.

As a result of the letter-ballot canvassed at the meeting on May 15, the Society decided not to lease quarters in the house of the Engineers' Club on Commonwealth Avenue, and at the same meeting authorized the board to extend the lease of its quarters in Tremont Temple and to acquire additional space. The board has leased about seven hundred square feet of floor space

adjoining the old rooms of the Society, and by the removal of a partition has been able to make a very satisfactory connection with the old quarters.

It is believed that the Society has now sufficient floor area to meet its needs for several years to come.

At the meeting held November 13, 1912, the Society appropriated from the Permanent Fund a sum not to exceed two thousand dollars to be expended for furnishing and fitting up its rooms. This amount is only about one hundred dollars in excess of the income of the current year applicable to the Permanent Fund. In other words, the Society has practically appropriated the income of the Permanent Fund for the current year for the changes and improvements. A portion of this money has been used for changing the partitions and other carpenter and plumbing work, and for the purchase of new furniture, including steel bookstacks and other furnishings, almost all of which are of permanent character and can be readily used wherever the Society may be located.

The electric-light fixtures have also been replaced by new ones, which not only afford better light but will enable lantern slides to be shown in the large room more satisfactorily than with the old fixtures.

With the enlargement of the rooms and the employment of a permanent assistant librarian, the Society has considerably increased its regular running expenses. These additional expenses apply to only a part of the year just closed, but resulted in an increase in the running expenses amounting to about six hundred dollars. In spite of this, the current income of the Society was about six hundred dollars more than the expenses of the year; and if the increased expenses had applied throughout the year, the balance would still have been about three hundred dollars on the right side. It appears, therefore, as shown in detail in the report of the Treasurer, that the Society is in a sound financial condition.

For the Board of Government,

James W. Rollins, *President.*

Annual Report of the Treasurer, 1912–13.

To the Boston Society of Civil Engineers:

Your Treasurer submits his report for the year ending March 19, 1913.

The financial information is contained in the four tables submitted herewith.

The income applicable to current expenses has been \$7 493.48, or about \$25 greater than that of the preceding year; the current expenses have been \$6 869.33, or about \$640 greater than for the preceding year,— a comparatively small increase, in view of the increased quarters and the employment of an assistant librarian, which have caused increased expenses for a considerable part of the year. The profit balance for the year has been \$624.15, or about half of that of last year.

The best estimate which it is possible to make at this time for next year indicates current receipts of \$7 500 and expenses of \$7 200, leaving a balance of \$300 available for unforeseen expenses.

There has been added to the Permanent Fund during the year \$1 902.70, or about ninety dollars more than for the preceding year. This sum is within

less than one hundred dollars of the two thousand dollars appropriated for alterations in rooms and for new furniture, etc. Of this appropriation, not quite half has been expended to date.

The present value of the Permanent Fund is about $31 000, including the unexpended balance of the appropriation, or $30 000 without this appropriation. The investment of this fund is such that, including the amortization of bonds bought below par, the net return must be about 4.9 per cent., but owing to the complexities of making such allowances, no attempt has been made to compute the rate of interest return.

Respectfully submitted,

CHARLES W. SHERMAN, *Treasurer.*

TABLE I. — PROFIT AND LOSS STATEMENTS.

Income:

	1909–10.	1910–11.	1911–12.	1912–13.
Members' Dues	$4 332.00	$4 567.00	$6 448.50	**$6 443.00**
Advertisements	850.00	1 004.50	984.50	**938.50**
Library Fines	3.50	4.75	5.56	**7.28**
JOURNALS sold	6.50	4.50	8.25	**9.40**
Interest	....	10.47	22.81	**95.30**
Total Current Income	$5 192.00	$5 591.22	$7 469.62	**$7 493.48**
Appropriation from Permanent Fund	....	....	....	**$2 000.00**
Entrance Fees	$670.00	$945.00	$410.00	**$525.00**
Contributions	100.00	200.00	100.00	**100.00**
Interest	659.07	1 231.78	1 301.72	**1 277.70**
Total Income Permanent Fund	$1 429.07	$2 376.78	$1 811.72	**$1 902.70**
Surplus Account	....	1.50	....	....
Balance, Deficit	334.18	940.26	....	....
	$6 955.25	$8 909.76	$9 281.34	**$11 396.18**

Expense:

	1909–10.	1910–11.	1911–12.	1912–13.
Association Eng. Societies...	$1 661.62	$1 912.62	$2 010.00	**$2 026.25**
Rent (net).................	950.00	856.74	920.00	**1 320.75**
Light.....................	48.54	53.76	49.68	**70.31**
Printing, Postage, Stationery,	1 397.48	1 770.96	1 356.99	**1 427.95**
Salaries..................	750.00	1 007.00	992.00	**1 248.50**
Reporting................	152.50	282.00	68.00	**20.50**
Stereopticon..............	135.00	180.00	130.00	**134.50**
Books.....................	83.00	72.10	40.53	**52.11**
Binding...................	73.20	81.20	169.30	**81.15**
Periodicals................	36.50	31.00	47.00	**34.25**
Incidentals and Repairs.....	41.83	79.45	84.94	**87.77**
Insurance................	8.88	26.38	26.38	**26.38**
Telephone................	....	59.82	65.24	**66.27**
Sanitary Section...........	60.00	45.00	14.24	**22.55**
Annual Meeting and Dinner.	118.88	43.45	220.82	**73.09**
Furniture.................	8.75	31.50	34.25	**2.50**
Navigation Congress.......	....	....	....	**20.00**
Students' Meeting.........	....	....	....	**154.50**
Total Current Expense....	$5 526.18	$6 532.98	$6 229.37	**$6 869.33**
Furniture.................	....	....	....	**$573.15**
Alterations in rooms.......	....	....	....	**375.45**
Total expended from Appropriation...........	....	....	....	**$948.60**
Permanent Fund...........	$1 429.07	$2 376.78	$1 811.72	**$1 902.70**
Balance of Appropriation....	....	....	....	**1 051.40**
Current Funds, Balance.....	....	....	1 240.25	**624.15**
	$6 955.25	$8 909.76	$9 281.34	**$11 396.18**

NOTES FOR 1912–13.

Dues.	Received from Secretary..........................	$6 453.00
	Deduct for 1913–14 Dues in advance...............	78.00
	Sum	$6 375.00
	Add Dues paid in advance last year.................	68.00
	Total Current Dues..........................	$6 443.00
Advertising.	Received from Secretary.....................	$942.50
	Paid Assn. Eng. Socs.........................	4.00
	Net earnings..............................	$938.50

Rent. Received from Secretary, rent paid by sub-tenants, as follows:

Hersey Mfg. Co.	$500.00
N. E. W. W. Assn.	400.00
N. E. Assn. Gas Engrs.	100.00
	$1 000.00

The gross amount of the rent for next year will be $2 611, including $90 for the use of Chipman Hall for nine meetings. The rent from sub-tenants will remain unchanged, making the net rent for the year $1 611.

Salaries. At the present rate, salaries for a full year will amount to:

Secretary	$400.00
Librarian	50.00
Asst. Librarian	720.00
Custodian of Rooms	100.00
Stenographer	416.00
	$1 686.00

Interest on Permanent Fund. The interest account has been charged with the difference between the book value and the amounts received for bonds sold during the year, and no account has been taken of the greater value of accrued interest at the end of the year than at the beginning.

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets:	March 20, 1912.	March 19, 1913.
Cash	$1 033.27	$353.26
Bonds	22 975.50	26 615.50
Coöperative Banks	6 667.83	5 315.80
Savings Banks	132.21	....
Accounts Receivable (rent)	145.83	145.83
Library	7 500.00	7 500.00
Furniture	600.00	1 175.65
	$39 054.64	$41 106.04
Liabilities:		
Permanent Fund	$30 031.14	$30 985.24*
Current Funds	686.00	1 310.15
Accounts Payable	237.50	135.00
Surplus	8 100.00	8 675.65
	$39 054.64	$41 106.04

* Including unexpended balance of appropriation, amounting to $1 051.40.

Table 3. — Investment of Permanent Fund, March 19, 1913.

Bonds:

	Par Value.	Cost.	Market Value.	Book Value.
Am. Tel. & Tel. Co. col. tr. 4s, 1929	$3 000.00	$2 328.75	$2 610.00	$2 737.50
Republican Valley R. R. 6s, 1919	600.00	616.50	612.00	618.00
Union El. St. & Pr. Co. 5s, 1932	2 000.00	2 050.00	2 020.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5s, 1939	2 000.00	1 995.00	1 960.00	1 995.00
Dayton Gas Co. 5s, 1930	2 000.00	2 000.00	1 980.00	2 000.00
Milford & Uxbridge St. Ry. 5s, 1918	2 000.00	1 952.50	1 980.00	1 952.50
Railway & Light Securities Co. 5s, 1939	3 000.00	3 000.00	2 940.00	3 000.00
Superior Water, Lt. & Pr. Co. 4s, 1931	3 000.00	2 505.00	2 505.00	2 505.00
Wheeling Electric Co. 5s, 1941,	3 000.00	2 895.00	2 895.00	2 895.00
Economy Light & Power Co. 5s, 1956	1 000.00	990.00	990.00	990.00
Tampa Electric Co. 5s, 1933,	2 000.00	2 000.00	1 960.00	2 000.00
Galveston-Houston Elec. Ry. 5s, 1954	2 000.00	1 940.00	1 900.00	1 940.00
Northern Texas Elec. Co. 5s, 1940	2 000.00	1 932.50	1 910.00	1 932.50
	$27 600.00	$26 205.25	$26 262.00	$26 615.50

Co-operative Banks:

25 shares Merchants Coöperative Bank (including interest to March)	$1 790.55
25 shares Volunteer Coöperative Bank (including interest to January)	3 373.75
15 shares Watertown Coöperative Bank (including interest to December)	151.50
	$5 315.80
Total	$31 931.30
Cash Deficit, borrowed from current funds	946.06
Total Permanent Fund, including unexpended balance of appropriation	$30 985.24

Note that 15 shares in Volunteer Coöperative Bank, amounting to $3 000, will mature in about two weeks. In anticipation of this, an investment in bonds has been made by borrowing from the current funds

TABLE 4. — CONDITION OF CURRENT FUNDS, MARCH 19, 1913.

Cash	$353.26
Loaned to Permanent Fund	946.06
Excess of Accounts Receivable over Accounts Payable	10.83
	$1 310.15

REPORT OF THE AUDITING COMMITTEE.

BOSTON, MASS., March 18, 1913.

We hereby certify that we have this day examined the books and records of the Treasurer of the Boston Society of Civil Engineers for the year 1912–13; that all receipts are properly accounted for and that there are proper vouchers for all expenditures.

We have also examined the securities and investments of the Society's funds, have verified and compared same with the books and found them all accounted for and properly carried.

We have compared the financial statement of the Treasurer with the books and find it to be correct.

CHAS. R. GOW,
ROBERT SPURR WESTON,
Directors.

ANNUAL REPORT OF THE SECRETARY, 1912–13.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS. *Dr.*

For cash received during the year ending March 19, 1913, as follows:

From entrance fees:			
47 members	at $10 =	$470.00	
1 associate		10.00	
9 juniors	at 5 =	45.00	
Total from entrance fees			$525.00
From annual dues for 1912–13:			
453	at $10 =	$4 530.00	
264	at 6 =	1 584.00	
33	at 5 =	165.00	
2	at 4 =	8.00	
		$6 287.00	
From new members		88.00	
Total dues for 1912–13			6 375.00
From dues for 1913–14			78.00
From sale of JOURNALS			9.40
From advertisements			942.50
From rent			1 000.00
From sale of bookcases			99.75
From contribution to building fund			100.00
Total			$9 129.65

Boston, March 18, 1913.

We have examined the above report and found it correct.

Chas. R. Gow,
Robert Spurr Weston,
Directors, B. S. C. Engineers.

Report of the Committee on Excursions.

Boston, March 19, 1913.

Excursions of the Society have been held during the year past as follows:

April 17, 1912. To Edison Service Station, Massachusetts Avenue, Dorchester, at the invitation of the Stone & Webster Engineering Corporation, engineers and contractors, to view the foundation work of the proposed buildings then in process of construction. The attendance of members on this occasion was 38.

September 18, 1912. To the Boylston Street Subway work, at the invitation of the Hugh Nawn Contracting Company, contractors for the work, to view the various features of construction then under way. The attendance of members on this occasion was 45.

February 19, 1913. To the Commonwealth and Fish Piers at South Boston, at the invitation of the H. P. Converse Company and Messrs. Tyson, Weare & Marshall, contractors for the work, to view the improvements undergoing construction at those places. The attendance of members on this occasion was 60.

The average attendance at the three excursions was 48.

It will be noted that your committee has seen fit to reduce the number of excursions materially from that of previous years. This policy was adopted because it seemed apparent that the interest manifested by the membership in the more frequent excursions did not warrant the annoyance and in some cases the expense to which our entertainers have often been put by reason of our visits.

The occasions when general interest in these excursions is aroused seem to be so comparatively infrequent that this committee is convinced of the wisdom of abolishing the excursion feature as such, leaving the matter in the hands of the Board of Government, who may provide for special excursions whenever in their opinion the importance of the event shall justify such action.

Your committee recommends, therefore, that the practice of maintaining a permanent excursion committee for the Society be abolished and that the duties previously assigned to such a committee be delegated to the Board of Government, to be exercised at its discretion.

The committee has on hand a balance of $52.94 which was carried over from last year and from which no payments have been made during the current year.

Respectfully submitted,

Chas. R. Gow,
Chairman, Committee on Excursions.

Report of the Library Committee.

The forty-second annual report of the library, for the year 1912–13, is herewith submitted.

The number of books added to the library the past year has been 757, of which 404 were bound in cloth and 353 in paper. As usual, most of the bound volumes consist of magazines, society publications and reports.

The library now contains 7 264 volumes bound in cloth. The total number in paper is about 2 000, but many of these will be bound in cloth later, thereby diminishing the number.

During the year 204 books have been loaned to members, and fines to the amount of $7.28 have been collected, an increase over previous years.

Fifteen volumes on engineering subjects have been purchased at an expense of $38.61.

During the past year the Society's quarters have been so enlarged as to afford ample room for the library and to provide for its growth for some years to come.

A second plan case for the Government topographical plans has been bought, also two steel double stacks, affording nearly three hundred linear feet of book shelving.

The books have also been rearranged with a view to growth.

The magazines have been bound as fast as the completion of the volumes would allow, also the town reports, and some society reports given to us in paper.

The reading room has been much better patronized since the changes have been made. An assistant librarian was engaged in October, and has been employed in re-arranging the library, in indexing, etc., up to date, and completing all files of reports so far as practicable.

All the volumes in the Herschel Library have now been bound in cloth, in conformity with the promise of the Society to Mr. Herschel.

A copy of the latest world's atlas (Cram's) has been purchased.

Two valuable sets of publications have been added, one by purchase, — the Proceedings of the National Fire Prevention Association, — the other a gift from the Municipal Engineers of the City of New York of all of their transactions.

The committee recommends that the sum of sixty dollars be appropriated for the purchase of current engineering books the coming year.

FREDERIC I. WINSLOW,
HENRY D. WOODS,
W. E. FOSS,
G. V. WHITE,
H. T. STIFF,
Committee on Library.

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 5, 1913.

To-night's meeting brings to a close the ninth year in the life of the Sanitary Section. Nine years ago, January 1, the first meeting of the Section was held at the Society rooms in Tremont Temple. A high standard for the meetings was set in the early days and has been maintained each year since. Your Executive Committee feel that the meetings of the past season have been no exception to the rule. Although required by the By-Laws to hold but

four meetings a year, namely, in March, June, October and December, during the past season six meetings have been held as follows:

	Attendance at Dinner.	Attendance at Meeting.
March annual meeting	26	40
June excursion	53	53
November special meeting	..	47
December meeting	17	47
January special meeting	..	50
February special meeting	..	64
Average attendance, not including the Excursion	..	50

This is the highest average attendance for seven years past.

The October meeting was omitted and the November special meeting substituted.

The June excursion was held in Worcester, Mass., where the Section, as guests of the city, inspected the Sewage Purification Works at Quinsigamond, and the work incident to the abolition of grade crossings along the Boston & Albany Railroad. The hospitality of the city was further extended in the form of a luncheon served in one of the city's parks.

The following subjects have been discussed at the meetings:

March 6, 1912. "Some Sewage Disposal Plants in Germany, France and England," Leonard Metcalf.

November 27, 1912. "The Sanitary Work of the Sanitary District of Chicago," Langdon Pearse.

December 4, 1912. "Refuse Disposal," Dr. Rudolph Hering.

January 8, 1913. "Ventilation," Prof. R. C. Carpenter.

February 5, 1913. "The Intercepting Sewer and River Improvements at Syracuse, N. Y.," Glen D. Holmes. "The New Bedford, Mass., Intercepting and Outfall Sewer," William F. Williams. "The Fitchburg, Mass., Intercepting Sewer," David A. Hartwell.

Some criticisms have been raised because more of the papers read before the Section have not been published. This is a difficulty which has confronted the officers of the Section for some time. We have felt justified in inviting speakers to come before the Section, even though they were unable to present a written paper, for the sake of the information received by those present at the meetings.

Whenever it has been possible to secure a written paper, the paper has been published in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

Four members of the Society have been enrolled in the Section since the last annual meeting. The total membership of the Section is now 165, of which 16 are members of the Sanitary Section only.

In December the Society suffered a great loss in the death of Mr. George A. Kimball, one of the fourteen signers of the petition which brought about the establishment of the Sanitary Section. He was honored and loved by all who knew him.

At the last annual meeting, the special committee on Uniform Specifications for the Manufacture of Sewer Pipe was continued in order to coöperate,

if possible, with a similar committee of the American Society for Testing Materials. Further work along this line has not been made possible during the last year, but the Executive Committee recommends that the committee be continued in the hopes that more definite results may be forthcoming in the near future.

The Committee on Rainfall and Run-off from Sewered Areas has been active and a large amount of laborious work has been done which will be of value to the profession.

During the past year, blank forms for sewerage statistics have been supplied whenever requested, but no work has been done in the way of tabulating such records.

For the Executive Committee,

Frank A. Marston, *Clerk.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., April 7, 1913. — A special meeting of the Civil Engineers' Society of St. Paul was held in the House Chamber of the Old Capitol, Monday evening, April 7, attended by 25 members. About 40 visitors were also present to hear a very interesting as well as entertaining lecture by Mr. Lynn White, chief engineer for the Board of South Park Commissioners of Chicago, on the subject of "Asphaltic Concrete as a Paving Material for Residence Streets." The lecture was well illustrated with stereopticon views of many of Chicago's streets where this material had been used. An able discussion followed, which was participated in by many of St. Paul's paving experts, and numerous suggestions were offered by Mr. A. B. Stickney, one of St. Paul's leading citizens.

This paper will be published in an early issue of the Association Journal and a careful study of it is especially commended.

L. S. Pomeroy, *Secretary.*

St. Paul, Minn., April 14, 1913. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held according to custom, on Monday evening, April 14, 1913, with 16 present.

The meeting was called to order by President Armstrong at 8.15. After the reading and approval of the minutes of the March meeting and the special meeting of April 7, Mr. A. F. Meyer, for the Public Affairs Committee, addressed the Society on the attitude which had been taken by his committee in regard to the bill before the Minnesota legislature, entitled, "A Bill for an act to require the State Board of Health to examine plans for, and to inspect, the construction and operation of all municipal and state water works and sewerage systems throughout the state except in cities of the first class." Mr. Meyer quoted from editorials in some of the leading engineering journals, expressing agreement with some of the sentiments therein set forth, while dissenting from others. He was also of the opinion that the revised laws of 1905 if properly applied would give the Board of Health about all the authority

necessary for public health regulation. Comparisons were also drawn between these laws and laws in the states of New York and Massachusetts enacted for a similar purpose.

On the whole, Mr. Meyer expressed the opinion that the bill in its present form was superfluous and ought not to become a law. It was remarked by Mr. Danforth, also of the Public Affairs Committee, that there was little chance of the bill getting beyond the committee stage at the present session, also that he had been informed that in case of any hearing, our Society would be notified. Remarks were made by Mr. Armstrong, also by Mr. Carroll, to the effect that the present legislature might more appropriately bend its efforts toward obtaining an appropriation for enforcing existing laws than to attempt to pass new laws which were not needed. A motion was finally carried that the Public Affairs Committee frame a resolution expressing the Society's disapproval of the pending bill and forward the same to the Committee on Public Health. This resolution follows.

Resolutions adopted by the Civil Engineers' Society of St. Paul at its regular meeting, Monday, April the 14th:

Whereas, under existing statutes of the state of Minnesota, it is provided that the State Board of Health shall take all necessary and proper steps to preserve all springs, wells, ponds and streams, used as a source of water supply for domestic use, from such pollution as may endanger the public health;

And whereas, the State Board of Health may adopt and enforce reasonable regulations for the preservation of the public health, which upon approval of the attorney-general and after due publication, shall have the force of law;

And whereas further, the State Board of Health may control by requiring the taking out of permits or by any other appropriate means, the pollution of streams and other waters and the distribution of water by private persons for drinking or domestic use;

Therefore, be it resolved, that we, the Civil Engineers' Society of St. Paul, while recognizing the fact that these existing statutes might be strengthened somewhat in the interests of the public health and might more clearly define the powers of the State Board of Health, believe that the bill now before your committee, entitled, "A Bill for an act to require the State Board of Health to examine plans for, and to inspect the construction and operation of all municipal and state water works and sewerage systems throughout the state, except in cities of the first class," grants powers and imposes duties upon the State Board of Health which are not properly within its province, and which will hamper municipalities in the construction and improvement of their water works and sewerage systems, and private individuals in the use of private water supplies.

We therefore respectfully request that your committee do not recommend the bill for passage in its present form and that you give the Committee on Public Affairs of this Society an opportunity to suggest modifications in the Bill before you take any action in the matter.

Civil Engineers' Society of St. Paul,

By Public Affairs Committee:

A. F. Meyer, *Chairman*.
O. Claussen.
Wm. Danforth.
T. N. Fowble.
G. A. Ralph.
H. E. Stevens.
Max Toltz.

Some remarks were made by Mr. Toltz with regard to a project for an appropriation by this legislature of $50 000 for investigating the "Mershon Scheme of Canalization of State Waters." He did not think that such an

investigation should be confined to merely examining Mr. Mershon's plans, but should carry with it authority to suggest other plans. A motion to refer a resolution, drawn up by Mr. Claussen to this end, to the Public Affairs Committee, was carried.

Mr. Herrold then took the floor and gave an outline of the methods in vogue of the American Railway Engineering Association, and thought that this Society might profitably employ somewhat similar methods for broadening its work. Upon motion by Mr. Carroll, a committee consisting of Messrs. Herrold, Danforth and King was appointed to draft an outline of some method having this end in view and report at some future date. Mr. Danforth offered a suggestion that the Public Affairs Committee be allowed to continue its work after the summer adjournment, to which no objection was raised.

The Secretary attempted to read a few communications from other organizations, asking for the opinion of this Society about matters of mutual interest, but it appeared to be the sense of the meeting that these were matters of no consequence and better passed over than taken up. Mr. King moved that no communications be read in the future, excepting such as might be authorized by the majority of the Governing Board of the Society, which motion carried.

Balloting for new members then followed with the result that the following were elected to full membership: H. A. Crampton, assistant engineer, Great Northern Ry.; O. L. Meigs, with the Corrugated Bar Company; S. Steenerson, district state highway engineer, Crookston, Minn.; H. H. Jewell, assistant engineer, with J. D. Du Shane; W. K. Tanner, assistant engineer, Great Northern Ry. F. W. Goldsmith, of the city engineering staff, was elected junior member.

No further business coming before the meeting, adjournment was taken about 10.30 P.M.

L. S. Pomeroy, *Secretary.*

Montana Society of Engineers.

Butte, Mont., March 8, 1913. — Meeting called to order, President Robt. A. McArthur in the chair, who appointed F. T. Donahoe Secretary *pro tem.* Members present: McArthur, Goodale, D. G. Donahoe, F. T. Donahoe, Bard, Carroll, Simons, Corry, Barker, Moulthrop, Dunshee, Bowman. Minutes of last meeting approved. The applications for membership of Messrs. Gow and O'Brien were presented, approved and ballot ordered. Several communications were read and referred to the Secretary for action. The following resolutions on the death of Frank A. Jones were approved, to wit:

Frank A. Jones — A Memoir.

Frank A. Jones, the subject of this brief sketch, was born in Pennsylvania on May 15, 1863. In 1886 he graduated in Civil Engineering from Lafayette University and at once went West, accepting a position with the Burlington & Northern Railway with headquarters in St. Paul, Minn. A year later he was transferred to the Burlington & Missouri Railway System, with headquarters in Lincoln, Neb., where he resided until 1894. During the eight years he served with the Burlington & Missouri Railway he had a large and

varied experience in railway construction, among the portions built by him being the Black Hills and Billings line, of which he had full charge He became an authority on "Spirals," the tables prepared by him still being used by engineers on that system. In 1894 he went to Anaconda, Mont., where he accepted a position on the engineering staff of the Butte, Anaconda & Pacific Railway, a year or so later being made chief engineer of the road. He joined the Montana Society of Engineers in 1904 and the same year was appointed superintendent of the Butte, Anaconda & Pacific Railway In 1905 he was made general superintendent, which position he filled until forced by illness to resign the same a year or more before his death. While acting as chief engineer of the Butte, Anaconda & Pacific Railway he located and built most of the existing lines around the Works there, and also made the final location of the line westward from Anaconda to the Bitter Root Valley. While residing in Lincoln, Neb., he was married to Miss Anne Pym, who, with their daughter, Miss Frances Jones, survives him. After a lingering illness of fully two years Mr. Jones died on January 3, 1913.

Mr. Jones was a member of Acacia Lodge, No. 33, A. F. & A. M., and of Anaconda Chapter, No. 16, R. A. M.; Montana Commandery No. 3, K. T., of Butte: and Algeria Temple, A. A. O. N. M. S., of Helena.

Your committee recommend the following resolutions:

Whereas, in the death of Frank A. Jones the Montana Society of Engineers has suffered the loss of one of its valuable members and the state of Montana a citizen who has left several lasting monuments to his engineering ability; and,

Whereas, Mr. Jones, through his indomitable perseverance and ability in his chosen profession, had risen to a prominent position where his good judgment had full sway and opportunity, thereby making the loss by his death the greater to the Society and the state, be it

Resolved, that the Society hereby express its appreciation of the loss it has sustained by the untimely taking away of Mr. Jones, and records its sincere sympathy with his surviving relatives in their bereavement; and

Resolved, that a copy of these resolutions be spread upon the minutes of the Society and a copy sent to the bereaved family of the deceased.

F. W. C. WHYTE.
C. A. LEMMON.
H. N. BLAKE.

The chair appointed the following Committee of Arrangements for the annual meeting: Carroll, Goodale, Bowman, McMahon and F. T. Donahoe. After considerable comment concerning the program for the next annual meeting, the Society adjourned.

F. T. DONAHOE, *Secretary Pro Tem.*

Technical Society of the Pacific Coast.

REGULAR meeting of the Board of Directors held at the residence of the Secretary, 1724 Broadway, on March 14, 1913.

The meeting was called to order by President Loren E. Hunt.

The Secretary read the minutes of preceding meetings, which were approved.

The Directors discussed at length the coming meeting to be held in conjunction with the annual meeting of the Pacific Association of Scientific Societies, and instructed the Secretary to prepare the necessary notices.

It was decided to hold the annual banquet of the Technical Society on or about April 25, and the President appointed the following committee to take this matter in hand and to make the necessary preparations for this annual event: Messrs. Schulze, Wright and Von Geldern.

Mr. Barth invited the Directors to hold the next regular meeting, on March 28, at his residence, No. 80 Sixth Avenue, which was accepted.

(Owing to the death [subsequently] of Mr. George F. Schild, member Tech. Soc., this meeting was postponed to a future date.)

The meeting adjourned.

OTTO VON GELDERN, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES

VOL. L. JUNE, 1913. NO. 6.

PROCEEDINGS.

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., APRIL 19, 1913. — A special meeting of the Civil Engineers' Society of St. Paul was held in the Grand Army room in the Old Capitol on the above date.

Mr. John Lyle Harrington of the firm of Waddell & Harrington, consulting engineers, of Kansas City, was in the city to superintend the placing in service of the new lift bridge of the Chicago Great Western Railroad over the Mississippi, and was present at this meeting, giving a very complete exposition of the principles of this particular type of bridge and showing many illustrations, by means of the stereopticon, of bridges built in different parts of the country by this firm. Mr. Harrington is a master in this line, and all who were present, who are at all interested in bridge construction, considered this lecture one of the most profitable given by the Society.

It was to be regretted that the very short notice of this visit given by Mr. Harrington did not permit a larger attendance of the members, as it was not possible to notify all of them, and many who were notified had made other arrangements. As it was, however, about thirty visitors in addition to the members attended, which made a very respectable audience. At the close Mr. Harrington was unanimously tendered a vote of thanks by those present.

L. S. POMEROY, *Secretary.*

ST. PAUL, MINN., MAY 12, 1913. — The regular monthly meeting of the Civil Engineers' Society of St. Paul was held according to custom on Monday evening, May 12, in the Council Chamber of the City Hall; present, fourteen members and about twenty guests.

President Armstrong called the meeting to order about 8.20, and introduced the speaker of the evening, Prof. Ervin McCullough, of the University School of Mines, who delivered a carefully prepared address on "American Metal Mining." Professor McCullough expressed in a very concise manner the wonderful development of the mining industry in the United States in the past few decades, and called attention to the relation existing between this development and that of almost every other known industry. At the close

of his address numerous illustrations of the points brought out were shown the audience by means of the stereopticon, and every one present felt well repaid for attendance, which appreciation was voiced by the Society's extending the professor a unanimous vote of thanks.

Mr. Herrold opened the business meeting which followed the address by moving to dispense with the customary reading of the minutes of the last meeting, which motion carried. Mr. Toltz followed with a suggestion that the outline of St. Paul's new city charter, as the same had been prepared by this Society's special committee, be given the city press, in order that all interested might become familiar with its provisions and be prepared to offer any suggestions by way of amendment. Mr. Rathjens, chairman of the above-named committee, thought that it would be better to wait until he had procured copies of the charters of the cities of Des Moines and Spokane, as he was in hopes after having seen these to have some amendatory recommendations to make. Mr. Herrold and Mr. Jurgensen both were in favor of publishing the outline. Mr. Palmer also thought that since this Society had a committee out for the express purpose of showing how in its opinion the charter might be improved, the outline might be published without creating the impression in the mind of the public that the charter in its present condition had the endorsement of this Society, which appeared to be Mr. Rathjens' objection to its publication. By motion of Mr. Van Ornum, it was finally decided to allow the city press to publish the outline. Mr. Rathjens observed that he would like to see this done, with the understanding that any recommendations as to the charter's amendment be sent to him as chairman of the Society's committee having this in charge.

Mr. Herrold as chairman of the committee appointed to suggest methods by which this Society might carry on a work similar to that now being carried on by the American Railway Engineering Association, reported that his committee had decided to wait until the summer vacation of the Society was over before making any recommendations.

Balloting for members then followed on the succeeding names: E. V. Willard, acting state drainage engineer; Lieut.-Col. Chas. L. Potter, Corps of Engineers, U. S. Army; Jas. A. Childs, assistant engineer, State Board of Health; Frank L. Hague, assistant engineer with the Toltz Engineering Company; A. A. Somersfield, assistant engineer with the Toltz Engineering Company; Thos. E. Ward of the City Engineering Staff. The latter application was for Associate membership.

On motion of Mr. Jurgensen, the Secretary was instructed to cast the ballot of the Society admitting them to membership as applied for in their respective applications.

Mr. Herrold announced, for the information of any who might be interested, that the American Water Works Association would hold a convention in Minneapolis during the week beginning June 23.

This completed the Society's business and adjournment was accordingly taken at 10.20 P.M.

L. S. POMEROY, *Secretary.*

Montana Society of Engineers.

Twenty-Sixth Annual Meeting, Held at Butte, Mont., April 10, 11, 12, 1913.

Thursday.— Was devoted to the completion of the program of entertainment concocted by the Arrangement Committee. Evidences on every hand gave promise of balmy air and favoring streets and skies. At eventide the Silver Bow Club hung out the flag of " Welcome, Engineers," and within its hospitable walls were rehearsed stories of other days, and friends met friends once again, strangers were made at ease, and the smoke of Havanas " rose like incense on the air."

Friday. — Promptly gatheied the explorers before the Silver Bow Club at the appointed hour. The weather surpassed expectations. Motor cars made ready for their voyage and voyagers. Soon the flagship of " The Admiral " was hoisted and the fleet sailed away, manned by an expectant, enthusiastic crew, bearing a gallant company. The " Hill " was the first anchoring place. Attractive points of interest were sought as varied desires controlled. Hissing steam and pulsating air compressors sounded their welcomes. Electric forces manifested their wondrous power. The labors and developments of brother engineers called forth the admiration of all who comprehended the magnitude of such efforts and their influence in the industrial world. Another coaling station was reached and a new curiosity in the mineral concentration world was inspected. The sailors were given every attention, and the noon hour came too soon for many. A speedy return was made to the home harbor and a delightful hour was had at a lunch at the club. Again the fleet weighed anchor and sailed away to the Pittsmont smelter, the Leonard mine, and various concentration plants of recent date and modern design. A part of the fleet sought anchorage near the Country Club House, securing there food and fuel for the return voyage. The afternoon was like one of January in length, like early June in airy comfort. The bow of the evening was laughed away in a sailors' theater, where fun and laughter held high carnival. The stern of the evening came to an end and a weary, contented crew sought their hammocks in a friendly port.

Saturday. — The business meeting of the Society was called to order in the Society Room in Silver Bow County Court House at the appointed hour, 10 A.M., President Robert A. McArthur in the chair. Fifty members were present. The President gave a short address of welcome, after which the minutes of the March meeting were read and approved. The Secretary presented applications for membership in the Society from Messrs. McLeod, Johns, Monroe, Williams, Cunningham and Buck. These applications were approved and ballots ordered. Messrs. Gow and O'Brien were elected to membership. The ballots for the officers-elect were then counted, Messrs. Blake and Good acting as tellers. The ballot was unanimous in favor of all the candidates, and President McArthur declared the officers elected for the year 1913 to wit: President, John H. Klepinger; First Vice-President, Reno H. Sales; Second Vice-President, Martin H. Gerry, Jr.; Secretary and Librarian, Clinton H. Moore; Treasurer and Membei of the Board of Managers of the Association of Engineering Societies, Samuel Barker, Jr.; Trustee for three years, Harry H. Cochrane. President McArthur presented President-elect Klepinger, who took the chair. The report of the Secretary was read

and approved after considerable discussion relating to his advocacy of an effort to increase the membership of the Society. The Treasurer's report showing $212.13 to the credit of the Society was approved as read. The Secretary presented the Good Roads Committee report for the past year, and on motion the report was approved, the same committee continued and authorized to send representative to any good roads conventions they thought best and use their judgments as to paying the expenses of such representative from the funds of the Society. Considerable discussion was had about obtaining more members and securing correct addresses of the members for the new Year-Book and resulted in the appointment of a committee consisting of Messrs. Klepinger, Moore and Smith, who shall carry out the plans developed by the discussion. It was voted that a committee be appointed each month by the chair to secure papers for the monthly meetings of the Society. Mr. Sales was appointed to arrange a program for the May meeting. Mr. Gerry submitted a brief verbal report on compiling the water resources of the state. Said report was approved. The Committee on Badges was given more time. Application for membership in the Society from Messrs. Mitchell, McGee and Buck were presented and approved and ballots ordered as soon as the applications were completed and properly endorsed. Various communications were read by the Secretary and filed or referred to the trustees. An exchange of library and Society room privileges was granted to the Baltimore Engineers' Club of Baltimore, Md. A recess was taken till 2 P.M. The afternoon session was held in Judge Donlan's court room for lack of space. The meeting commenced with the reading of the retiring President's address by the author, which contained a very great amount of valuable information, concisely stated. The address was ordered printed in the JOURNAL of the Society. Mr. A. E. Wiggin gave an account of his visiting trip to the various smelters and concentrators throughout the country. His talk was informal, but contained much general information on ore reduction. Mr. W. J. McMahon gave a clear statement of his experiences in the last state legislature in attempting to secure the passage of a measure known as a General Highway Law, which was prepared by the Good Roads Committee of this Society. Mr. Sales made a few brief comments on a few geological features of the Butte camp. An amendment to the By-Laws was offered to change the date of the monthly meeting from Saturday to Monday, except the annual meetings. The amendment was laid over till the next meeting for disposal. The Secretary was instructed to express the sympathy of the Society to Mr. J. C. Adams for his enforced absence caused by illness. The thanks of the Society were voted to all who had contributed to the success of the annual meeting of the present year, after which adjournment followed. The usual banquet was had at the Silver Bow Club.

CLINTON H. MOORE, *Secretary.*

Louisiana Engineering Society.

NEW ORLEANS, APRIL 14, 1913. — The meeting was called to order at Tulane University with President Shaw in the chair and a number of members and guests present.

Upon motion the business of the evening was dispensed with and the technical exercises were taken up. Mr. H. L. Collier, consulting engineer of

the Yellow Pine Manufacturers' Association of St. Louis, delivered a very interesting lecture on the "Development of Creosoted Wood Blocks as Paving Material in the United States." The lecture was profusely illustrated with lantern slides and the discussion at the end added not a little interest to the evening. The meeting being held primarily for the lecture, there was no further business to be transacted and the same was adjourned.

James M. Robert, *Secretary.*

Utah Society of Engineers.

Salt Lake City, Utah, April 18, 1913.—The annual meeting and dinner of the Utah Society of Engineers was held at the Hotel Utah on the evening of April 18, 1913.

About fifty-two members and friends were in attendance.

After an enjoyable dinner, the meeting was called to order by President Brown. The vote by letter-ballot for officers of the Society for the ensuing year resulted as follows:

President — A. S. Peters, division engineer, Mountain States Telephone and Telegraph Company. Second Vice-President — H. D. Randall, electrical engineer, General Electric Company. Secretary — Fred D. Ulmer, assistant engineer, Oregon Short Line Railroad Company. Treasurer — L. H. Krebs, engineer sewers and drains, City Engineer's Department. Member Executive Committee — W. A. Wilson, mining engineer. These, with Messrs. R. K. Brown, Past President, division engineer, Maintenance of Way, San Pedro, Los Angeles & Salt Lake Railroad Co.; and E. H. Beckstrand, First Vice-President, professor of mechanical engineering, University of Utah, to constitute the Executive Committee for the ensuing year.

Following the election of officers, the Society was favored by the annual address of the retiring President, R. K. Brown, who gave a brief résumé of the business and progress of the Society during the past year.

The report of the Secretary and Treasurer, being in printed form, was not read, but instructions were given to forward a copy to each member.

Following the business meeting, Mr. Lafayette Hanchett was introduced as toastmaster, who, after a brief speech, called for responses to the following toasts: "Gentlemen, Your Contribution," by Dr. F. B. Short; "Engineers and Service," by Dr. J. F. Merrill; "A Few Remarks," by Judge E. F. Colborn.

Adjourned.

Fred D. Ulmer, *Secretary.*

Annual Report of the Secretary, Year 1912–1913.

The following is a summary of the work done by the Society during the year:

Programs of Meetings Held.

Date of Meeting.	*Subject.*	*Speaker.*
June 21.	Entire meeting devoted to the revision and discussion of the new Constitution submitted by the Executive Committee.	
Sept. 20, 1912.	"Weir Measurement of Water." (At this meeting our present Constitution was adopted.)	Richard R. Lyman.

Date of Meeting.	*Subject.*	*Speaker.*
Oct. 18, 1912.	"Street Paving in Salt Lake City."	John Duder and D. H. Blossom.
Nov. 15, 1912.	"Electric Power Supply for Utah."	H. D. Randall.
		Markham Cheever.
		Leonard Wilson.
		C. A. Cohn.
		G. W. Riter.
Dec. 20, 1912.	"Mineral Resources."	
	Park City District.	F. D. Blood.
	Bingham District.	J. Fewson Smith.
	Tintic District.	Walter Fitch.
Jan. 17, 1913.	"Petroleum Oils and Their Refining Value."	J. C. Howard.
	"Geology of the Oil Fields of Utah."	Dr. F. J. Pack.
Feb. 21, 1913.	General Subject — Reclamation.	
	"Drainage of Water-Logged and Alkali Lands."	R. A. Hart.
	"The Strawberry Project."	J. L. Lyter.
	"Collateral Benefits of Irrigation."	Arthur P. Davis.
March 21, 1913.	"Properties of Steel Alloys."	Dr. A. A. Knowlton. Prof. E. H. Beckstrand.
April 18, 1913.	The Annual Dinner.	

A special meeting is also arranged for April 19, at which a lecture is to be given by H. B. McMasters on the subject of "Fire Proofing," in the Consolidated Music Company Hall.

Entertainment.

On January 18, the members made an inspection trip to the plant of the Utah Oil Refining Company.

In connection with December meeting the members took dinner at the Moxum Hotel, and previous to the February meeting a cold supper was served for the members at the Commercial Club.

Membership.

At the beginning of the year the Society had 85 members in good standing. At present we have 104 members, 7 Associates and 6 Juniors, a total of 117.

Financial.

During the year I have collected and turned over to the Treasurer $542.50. An itemized list of all receipts and a list of members in good standing revised to date is filed as a part of this report.

Respectfully submitted,

R. B. Ketchum, *Secretary.*

Annual Report of the Treasurer, Year 1912–1913.

As Treasurer of the Utah Society of Engineers, I have the honor to submit the following report for the year terminating, for this Society, with the annual election of officers, as provided in Article 8, Section 2, of the Constitution, which states that "the annual meeting shall be held on the third Friday of April in each year."

Receipts.

Cash on hand April 19, 1912 (amount received from my predecessor)		$235.50
Collections:		
Dues received from members for 1912–13	$416.50	
Initiation fees received from new members	126.00	
		542.50
Total receipts during the year 1912–1913		$778.00
Disbursements:		
Four assessments JOURNAL ASSOCIATION ENGINEERING SOCIETIES	$236.88	
Printing and stationery	121.86	
Stenographic services	33.30	
Postage	14.92	
Rent account, Stock and Mining Exchange	15.80	
Rent of chairs for meetings	17.00	
Janitor services	2.00	
Miscellaneous items	5.10	
		$446.86
Balance on hand		331.14
		$778.00
Resources:		
Deposit with Utah Savings and Trust Company		$331.14
Office furniture and fixtures (estimated cost)		115.00
Publications on hand (estimated cost)		35.00
Dues from members		163.50
Total resources		$644.64
Liabilities:		
None		000.00
Net resources		$644.64

Respectfully submitted,

L. H. KREBS, *Treasurer.*

Dated APRIL 12, 1913.

Oregon Society of Engineers.

THE annual outing of the Oregon Society of Engineers was held on May 17, and was taken in the form of an excursion to the State University at Eugene, 123 miles from Portland. Members of many other organizations in the city were invited to join the excursion, and a large number did so. The party left Portland at 7.30 on the Oregon Electric Railway, lately completed

to Eugene. There were two hundred and two persons in the crowd, and about one hundred more were taken on at Salem and Albany. Many were prevented from going by a rainy morning.

Eugene was reached at 11.00 o'clock. Automobiles were waiting at the station to convey the party through the city, and to the university, where the closing address of the Commonwealth Conference was heard, and addresses of welcome were made by Mayor Yoran and President Campbell of the university. President Graves of the Oregon Society of Engineers and President Kerr of the Oregon Agricultural College replied.

An excellent dinner was furnished in the gymnasium, the lady students serving. Humorous singing expressing our appreciation of the welcome received, and our support of the university, was started by Mr. Werlein of the Transportation Club. A short forcible address was made by C. C. Chapman, of the Portland Commercial Club, and it was moved to draft resolutions to express the body's support of the university, and the apparent great need of state aid.

After the dinner the engineers listened to a paper on "State and National Coöperation in the Development of Oregon's Water Resources," by Frederick Henshaw, district engineer of the United States Geological Survey, and a paper by John Lewis on "The Problem of the Development of Oregon's Power Resources." A short discussion followed, after which the chairman, Mr. H. B. Miller, was authorized, on motion of Professor Young, to appoint two important committees looking to the study and practical development of the irrigation and water power of the state. Some members of the party then visited the various buildings of the university, but most of them gathered at Villard Hall, where the students presented the play of "Peer Gynt" and part of the "Midsummer Night's Dream." The ladies were then served with supper at the Hotel Osburn, and the men at the Commercial Club.

All agreed that a more pleasant time could hardly have been spent.

The train left for Portland at 8.00 o'clock and arrived there at 11.30.

Henry Blood, *Treasurer.*

Barker